The Foundry Trade Journal

AND PATTERN-MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 11. **NOVEMBER, 1909.** **No. 95.**

PUBLISHED THE FIRST WEEK IN EACH MONTH.

Subscription Terms: 7s. 6d. per annum, post free.

To place the "JOURNAL" within the reach of Working Moulders and Pattern-makers the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum, such order to be countersigned by the superintendent or foreman.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
165, Strand, London, W.C.

WE INVITE PRACTICAL ARTICLES ON THE TRADE IN ALL ITS BRANCHES, WHICH WILL BE PAID FOR MSS. SHOULD BE WRITTEN ON ONE SIDE OF THE PAPER ONLY.

BRITISH FOUNDRYMEN'S ASSOCIATION.

LIST OF SECRETARIES—

General Secretary: J. E. H. Allbut, Reservoir House, Butterley, Derby.

Manchester: H. Sherburn, Rotherwood. Stockton Heath, Warrington.

Birmingham: C. Heggie, 76, Hillaries Road, Erdington near Birmingham.

Cardiff: H. Griffiths, Messrs. J. Williams & Sons, Ltd., Globe Foundry, Cardiff.

Sheffield and District: Thos. Swinden, 28, Holland Road, Sheffield.

Contents.

	PAGE
Notes and Comments	658
The "Growth" of Cast Irons after Repeated Heatings	659
A Regeneratively Heated Crucible Furnace	668
The Making of Patterns for Cast Gears	670
Staff Organisation in Large Manufacturing Plants	671
Jolt-Ramming Moulding Machines and Foundry Methods	672
The British Foundrymen's Association (Sheffield Branch)	673
The Herman Jarring Moulding Machine	675
A Car Wheel Chill	676
A System for Pattern Storing	677
The Hauck Oil-Burning Process	679
Microscopy in the Foundry	680
The Casting of Brass	682
Institute of Metals	684
Green-sand Cores	686
The Electric Smelting Process for Iron and Steel	688
Cupola Operation	689
Pipe Moulding	690
The British Foundrymen's Association (Birmingham Branch)	692
Correspondence	696
Queries	696
Inventions	697
Trade Talk	700
Personal	702
Deaths	702
New Companies	704
Prices of Metals	706

Forthcoming Events.

NOVEMBER 6TH.

British Foundrymen's Association (Sheffield Branch).—"The Scope of Science in the Foundry," by Richard Mather, B.Met., Middlesbrough.

NOVEMBER 20.

British Foundrymen's Association (Sheffield Branch).—"Modern Bronzes," by R. H. Greaves, B.Sc., Birmingham.

NOTES AND COMMENTS.

Mixing Cast Iron and Steel.

In these columns last month we remarked on the use in Germany of a mixture of steel and iron in the form of a specially cast pig, for producing a suitable mixture for casting cylinder and similar work. This subject is, of course, a very important one to British makers of cold-blast pig-iron particularly, for the alloy recommended by Henning, which we referred to, is obviously designed to obviate the use, to some extent, at least, of our pig-irons by German foundries. A correspondent, in a letter which we publish on another page, remarks that it is astonishing that high-priced cold-blast irons are still finding a ready market, since the use of steel scrap is more and more advocated for obtaining a dense and close-grain, as well as a great tensile and transverse strength, but proceeds to suggest that these are not the only physical properties for a good cylinder metal. He also remarks on the fact that whereas French foundries formerly made a regular practice of melting a charge consisting of scrap iron and scrap steel, or pig-iron and scrap steel, and casting the metal into pigs for use in the cupola to produce dense castings, now the use of this "lingotage," or ingot material is diminishing. The next paragraph of our correspondent's letter, however, probably supplies the explanation, for taken in conjunction with the extra cost of melting the scrap and casting into ingots, the care which is necessary when steel is added to the cupola if shrinkage and other troubles are to be avoided, would rather tend to prejudice founders against the use of steel. The advance of chemistry, also may help to account for the change in practice, for as it becomes more a matter of daily routine to calculate closely the constituents of the metal charged into the furnace, so does the use of steel in a more or less empirical manner become unnecessary. This point was touched on in another article in our last issue on "Kish and the Making of Solid Valve Castings," which dealt essentially with American practice and American pig-irons. It was there shown that the use of analytical methods in determining the mixture for such work can overcome the troubles that beset the maker of valve castings.

We do not think that the fact that the use of steel in this form has not gained any prominent consideration in this country is particularly significant, as regards its adaptability for the work mentioned, for the conditions obtaining here, and the irons available rather discount the importance to us of any such advantages it may possess. It is essentially a matter for those who are in a similar position to the German founder; and while the fact that the matter is still being discussed in American and Continental foundry circles, and also the fact that a great diversity of opinion exists in those countries as regards the use of steel scrap, may suggest that too much is often claimed for it, it must be remembered that there are a number of foundrymen who are using it continuously, and with considerable success.

The "Growth" of Cast Iron.

Although the researches of Professor Rugan and Professor Carpenter on the "growth" of cast iron after repeated heatings, which we deal with in the following pages, open up more questions than they actually settle, their investigations are none the less welcome, for they present several conclusions which are practically definite. It is interesting to note, also, that a general agreement with the earlier conclusions of Mr. Outerbridge, the well-known American investigator, is recorded, although Professors Rugan and Carpenter claim that his conclusions will require to be modified. As regards the points of disagreement, we note that Mr .Outerbridge, in a contribution to the discussion which he has forwarded, remarks that the internal evidence in the paper itself, upon which these diverse views are formed, proves very conclusively indeed the correctness of his original statements. The authors state that their experimental results with the two alloys A and M are in disagreement with his opinion that white iron, in which nearly all of the carbon is in the combined form, does not expand sufficiently to overcome the original shrinkage even after all of the combined carbon has been changed to graphite, and claim to conclusively show that it does. Mr. Outerbridge, however, claims that a study of their tabulated tests, conclusively shows that it does not. The linear contraction or shrinkage of white cast iron, he says, on cooling from liquid to solid is about 0.3 in. per foot, as compared with about 0.125 in. per foot for ordinary grey foundry iron. The alloys A and M referred to were white iron bars, approximately 6 in. in length. The original shrinkage of the metal of the bars was, therefore, about 0.150 in. in each bar. The original length of alloy M bar was 6.1317 in.; the final increased length, after 68 heatings, was 6.2040 in., a total linear expansion of 0.0723 in., as compared with original shrinkage of the metal of this bar of 0.165 in. In other words, it had recovered, after 68 heatings, a little less than one-half of the original shrinkage. The original length of bar alloy A (also white iron) was 5.9587 in.; the final length after 90 heatings was 6.0870 in., a total linear expansion of 0.1283 in., as compared with the original shrinkage of 0.150 in. It then appears that in neither of the cases cited did the white iron bar expand sufficiently to overcome the original shrinkage, even after all of the combined carbon had been changed to the graphite form; and this agrees with practical experience in annealing malleable iron castings.

The authors also state that they have great difficulty in accepting the statement that Mr. Outerbridge's enlarged bar weighed precisely the same as before treatment; but that gentleman explains that when he at first heated the bars in a muffle of a furnace, as did the authors, he found that a constant stream of air passing over the white hot bars caused "scaling," due to oxidation, and this oxidation penetrated the metal in a manner analogous to the penetration of carbon in case hardening mild steels. This scaling always caused an increase in weight of the expanded bars. Mr. Outerbridge filled the spaces between the bars, in the metal tube in which they were enclosed, with charcoal; but even without this precaution there was sufficient carbonaceous material present to prevent scaling, and the conditions, moreover, did not permit of the penetration of oxidising gases and were thus not similar to those used by the authors.

These differences in the conditions under which the heating of the specimens took place go a long way to explain the discrepancies between the conclusions of Mr. Outerbridge's experiments and those of Professors Rugan and Carpenter.

The results recorded by the anthors can scarcely be said to have been carried to the point where useful practical application may be made, though the importance of the experiments and conclusions is nevertheless considerable. It will be noted that no specific gravity determinations have been made, nor are any breaking tests given. A wide field for investigation and experiment has been opened, and the next few years will doubtless see great advances on the lines that have been commenced.

Retrenchment During Business Depression.

Not uncommonly do foundry owners, when lack of orders and general business slackness eases the pressure of work on hand, commence to cut down expenses by reducing the number of employés, and generally leaving the works and plant to run on just the incoming business. While this is the natural course to follow at such times, it is possible to carry it too far, and instead of serving the interests of economy to lose valuable opportunities of putting in order many things that have to stand over during business pressure. Consequently it is a short-sighted policy to follow too far what appear at first to be the dictates of economy. It would, of course, be foolish to attempt to keep fully engaged the whole of any plant in the absence of orders to operate upon, unless some stock manufacture was being turned out, but in a foundry, particularly, there are a number of matters that may well receive attention at such times. In some cases a re-arrangement of the equipment that would prove advantageous in the future could be carried out, or attention could be turned to over-hauling the foundry appliances and putting them in order. Moulding boxes, perhaps, require repairing or renewing, or the system of storing patterns may need re-organising. These and numerous other matters are often not of sufficient immediate importance to be attended to when the works are full of orders, but they are matters that count in the ultimate economy of the foundry and need consideration. In addition to these outlets for attention during slack time there are often problems and difficulties which have involved loss in the past, and which might well bear investigation when other work is not on hand. Too often all operations which cannot be charged direct to definite accounts and so show a direct return are regarded as waste, but no greater mistake could be made than to suppose that such work as that just mentioned is to be counted as loss. It must always be borne in mind that efficiency ultimately spells profit, and therefore the efficient upkeep of the plant and equipment of the foundry, and the attainment of efficiency in the operations entailed in the work, is as much an economical consideration as is the reduction of the wages bill to the lowest practical point. There are many foundry managers who consistently attempt to keep the wages bill down in order to effect economical working, but who would regard it as rank extravagance to spend the time of a couple of men during a slack period in investigating the possibilities of, say, cheaper brands of pig-iron suitably mixed for obtaining the metal required for certain work. It would involve a direct immediate outlay without any immediate return, but it would probably result in savings in the future that would quite eclipse the immediate expense. To set one's house in order and to establish more systematic and correct methods of operation must not necessarily be counted a wasteful undertaking; in fact, it is really a most essential undertaking if ultimate economy is to be attained, and the time of trade slackness is the time to do this work.

The "Growth" of Cast Irons after Repeated Heatings.

By Professor H. F. Rugan,* and Professor H. C. H Carpenter, M.A., PhD.†

At the meeting of the Iron and Steel Institute in London, on September 28, a paper was presented by Professors Rugan and Carpenter on the subject of "The 'Growth' of Cast Iron after Repeated Heatings." Owing to the length of the paper it is impossible to publish here more than the following abstract:—

The fact that certain types of cast iron "grow" after repeated heatings has long been familiar to engineers. Cast-iron annealing ovens 8 ft. in length, 3 ft. in diameter, and 1½ in. in thickness, which are kept red hot for prolonged periods, sometimes "grow" to 9 ft. in length in the course of use. Cast-iron furnace grates, range fittings. etc., which are subject to alternate heating and cooling, are frequently distorted and sometimes broken from the same cause.

Further, it is well known that wrought iron contracts permanently after repeated heatings. Mr. Humphrey Wingfield, who drew the attention of one of the authors to these facts in a correspondence arising out of his paper, entitled "Structural Changes in Nickel Wire at High Temperatures,"‡ suggested that these might be related phenomena, and that it would be interesting to discover an alloy intermediate between cast iron on the one hand, and mild steel and wrought iron on the other, which neither expanded nor contracted after repeated heatings. This problem has been taken up by the authors.

Previous Work Bearing on the Investigation.

Mr. A. E. Outerbridge, junr., of Philadelphia, has been the principal, indeed almost the sole, worker in this field, so far as the authors have been able to learn. His chief contribution to the subject is entitled "The Mobility of Molecules of Cast Iron."§

Mr. Outerbridge's summary of his experiments is as follows: "All of the investigations so far made in expanding cast iron by heat, whether by pouring molten iron over cold bars, heating in a closed tube with or without charcoal, heating in a fire without any protection, or by direct radiation over a fire far removed from the flames, . . . produce practically the same results, and tend to convince me that the astonishing change in volume is a molecular, not a chemical, one; thus substantiating my original theory of the molecular mobility of cast iron.

"The peculiar property of cast iron of increasing in bulk under the influence of heat is inherent in the metal, and has existed for all time. It must therefore have been noticed to some extent long ago; but so far as I am aware, no careful study has ever been made of the phenomenon, if it was observed, and no previous knowledge has, I believe, existed of the fact that a bar of iron can be increased in bulk more than 40 per cent. over its original volume while in the solid condition and still retain its metallic properties."

Photomicrographs of the untreated and treated cast iron are given, from which Mr. Outerbridge concluded that the particles of iron were pushed apart by heat and did not return to their original positions when cold, but that the arrangement of the crystals was similar in both specimens.

In another account of the same work, published in the "Journal of the Franklin Institute," April, 1904, Mr. Outerbridge puts forward the view that the pressure caused by the expansion of occluded gases in cast iron plays a prominent part in the growth observed, and that these gases ultimately escape through the pores of the metal which have been expanded, the intermolecular spaces becoming filled with air. This is the only hint of the mechanism of the growth contained in his publications. The obvious reply to this is that mild steel also contains a considerable quantity of gases, and that if they are the cause of growth in cast iron, then mild steel should also grow for the same reason. Like all good pioneering work, Mr. Outerbridge's investigations raise more questions than they settle, and a study of his papers led the authors to undertake a very extensive series of experiments, which they believe will be found to throw light on the interesting facts observed by him, and to give a clearer idea of the cause or causes at work in the permanent growth of many types of cast iron. These scientific investigations have contributed materially to the solution of the practical problem—"Can a commercial cast iron be made which neither expands nor contracts after repeated heatings?"

Experiments to Determine the Conditions under which the Maximum Growth of Cast Iron takes place.

A grey cast iron was selected for this purpose. Bars of known length were heated in an electrically warmed tube furnace at certain temperatures and for certain periods, the temperature being measured by a platinum platinum-iridium thermo-junction and direct-reading portable pyrometer. Three bars were heated at a given temperature. One was removed after one hour, another after two hours, and the third after three, or, in some cases, seventeen hours. When cold they were re-measured. Table I summarises the results obtained.

TABLE I.

Heat No.	Temperature.	Bar No. 1.		Bar No. 2.		Bar No. 3.	
		Time.	Growth in Inches.	Time.	Growth in Inches.	Time.	Growth in Inches.
1	600° C.	1 hour	nil.	2 hours	nil.	3 hours	nil.
2	630° C.	,,	nil.	,,	0·0020	,,	0·0020
3	675° C.	,,	0·0156	,,	0·0250	,,	0·0300
4	700° C.	,,	0·0234	,,	0·0342	,,	0·0312
5	730° C.	,,	0·0312	,,	0·0345	,,	0·0302
6	760° C.	,,	0·0313	,,	0·0350	17 hours	0·0352
7	800° C.	,,	0·0313	,,	0·0350	,,	0·0352
8	880° C.	,,	0·0313	,,	0·0350	,,	0·0352
9	900° C.	,,	0·0315	,,	0·0352	,,	0·0355

As 900 degrees C. is doubtless reached, and perhaps to some extent exceeded, in some of the practical uses of cast-iron annealing ovens, the authors selected it for their later experiments, and in order to ensure maximum growth for a given heat the period of heating chosen was four hours.

* Tulane University of Louisiana, U.S.A.; Research Fellow in Metallurgy, Victoria University, Manchester.
† Professor of Metallurgy, Victoria University, Manchester.
‡ "National Physical Laboratory: Collected Researches, vol. iii., pp. 259—268. H. C. H. Carpenter.
§ "Transactions of the American Institute of Mining Engineers 1905," vol. xxxv., pp. 223—244.

Series of Experiments with Commercial Cast Irons.

Three irons were selected. The first was a mixture used by a firm for the manufacture of annealing ovens. The second was a mixture as far removed from the first in composition as they used. Bars of these were cast as follows:—Four flasks were set up, two of green sand and two of dry sand construction, from each of which four bars were cast. The gate was in the centre, and the bars were fed from the bottom, the top of the mould being open. Before pouring, the dry sand flasks were heated by bars of red-hot iron. One flask of each kind was poured from the same ladle, the only difference being that the bars cooled at a different rate. These bars are designated PH (hot), PC (cold), FH, and FC. The third sample was a bar cut from a new annealing oven obtained from another source, and is designated NIP.

These five samples were heated ninety-nine times for four hours at about 850 degrees to 950 degrees C. The summary given in Table II., however, brings out the main features of the growths observed.

So far as carbon and silicon are concerned the compositions of the three alloys were not greatly different. Alloys PC, PH, and NIP grew rapidly, and reached 50 per cent. of their ultimate growth after ten heats. After twenty-one heats their rate of growth became very slow. Alloys FC and FH grew more slowly at the outset, but ultimately nearly caught up the others. The rate of growth of PC and PH was very similar throughout, whereas FH, a more "open" iron than FC, grew more rapidly at the outset. In both series, however, the ultimate growth was nearly the same,

TABLE II.

Alloy.	Percentage.		Percentage Increase of Volume.				Percentage Increase of Weight after 99 Heats.
	Carbon.	Silicon.	After 10 Heats.	After 21 Heats.	After 52 Heats.	After 99 Heats.	
PC . .	3·48	1·13	19·90	27·80	32·40	37·50	8·60
PH . .	3·48	1·13	19·90	27·46	31·50	36·00*	8·50
FC . .	3·41	0·95	8·71	13·25	26·05	35·21	7·86
FH . .	3·41	0·95	13·05	22·45	28·10	35·70	7·82
NIP . .	3·14	0·96	19·30	23·15	27·70	35·60	7·90

* Percentage growth after ninety-four heats.

irrespective of the initial rate of cooling of the alloy, varying from 35.21 to 37.50 per cent.*

Although the ends of the bars grew rather more rapidly than the sides, and numerous small cracks formed on the surface as the heats progressed, their ultimate shape was cylindrical. An increase in the weight of the bars also took place, the rate being more uniform than in the case of the volume increase. The percentage increase after ninety-nine heats varied from 7.82 to 8.60.

Summarising the results of this series of experiments, it may be said that in their general features they are similar to those obtained by Mr. Outerbridge, with one important difference, viz., that whereas he states the weight of his enlarged bar was precisely the same as before treatment, the authors found a progressive increase in weight as growth proceeded. It is unnecessary at this stage to do more than note this difference. It will be discussed later.

Long before these experiments were concluded it had become clear that the first step to be taken in the elucidation of the cause or causes at work during the growth of cast-iron by repeated heatings was to correlate "growth" with the composition of the material. This aspect of the investigation had been left untouched by Mr. Outerbridge. It was, of course, necessary to begin with simpler materials than the complicated cast irons of commerce, and the first series of alloys was designed so as to contain, as nearly as industrial processes permit, only iron and carbon. This series, and the remainder of the series of alloys mentioned in this investigation, were cast at the Openshaw Works of Sir W. G. Armstrong, Whitworth & Company.

Iron-Carbon Series.

The compositions of the iron-carbon series are given in Table III. The carbon descends broadly in half per cents. from 4 to the lowest carbon alloy that could be cast (0.15). The remaining constituents are present in sufficiently constant and, in the case of sulphur and phosphorus, small amounts. The rather higher figure for sulphur in alloy I was caused by the greater time needed for melting. This series proved quite satisfactory for the purpose for which it was intended.

Each alloy was cast both in sand and chill moulds, the diameter of the bars being 1 in. About 25 lbs. of each were available. In no case was any graphite present; the alloys were exclusively white irons.

Machined bars of these alloys were subjected to as many as ninety heats in some cases. The chill castings were too hard for turning. Approximately a 6-in. length was ground in the lathe, the bar being held in a chuck while an emery-wheel was fed across the end surface. This gave a suitable form for length measurements. Near the centre of this bar a space of about 1 in. was ground to a true surface, and

TABLE III.

Alloy.	Percentage.				
	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
A	4·03	0·243	0·15	0·018	0·010
B	3·70	0·223	0·16	0·018	0·011
C	3·08	0·173	0·13	0·019	0·010
D	2·59	0·146	0·12	0·016	0·012
E	1·95	0·215	0·20	0·013	0·015
F	1·58	0·168	0·17	0·015	0·014
G	0·99	0·233	0·19	0·015	0·012
H	0·55	0·182	0·20	0·013	0·014
I	0·15	0·186	0·15	0·040	0·017

served for diametric measurements. The remainder of the surface was left as cast.

These samples retained their shape throughout the heat treatment. In the case of alloy A the thickness of the scale after ninety heats was about 0.0015 in. This tended to increase as the carbon of the series diminished. The sand castings were less hard. They were turned to about 0.75 in. diameter in the form of 6-in. lengths. Alloys E, F, G, and H contained a number of blowholes. The maximum temperature of the various heats was 960 degrees C., the minimum 800 degrees C. Tables IV. and V. summarise the ultimate changes of volume and weight after the last heat.

TABLE IV.—*Chill Cast Alloys.*

Alloy.	No. of Heats.	Percentage Change of Volume.	Percentage Change of Weight.
A	90	+6·980	-1·21
B	90	+0·238	-1·36
C	87	-0·840	-1·29
D	87	-0·922	-0·97
E	87	+1·140*	-0·75
F	48	+0·200*	-0·43
G	48	+1·260*	-0·12
H	48	+0·113*	-0·02
I	48	+0·800*	+0·03

* These figures are high, on account of the scale which formed to a greater extent on the lower carbon members of the series. The same holds for the sand castings.

* The volume of PH after ninety-four heats is introduced for purposes of comparison. After ninety-nine heats scale on the bar became detached and it was difficult to get an accurate measurement. The value for PH is thus slightly low, but not much

TABLE V.—*Sand Cast Alloys.*

Alloy.	No. of Heats.	Percentage Change of Volume.	Percentage Change of Weight.
B	78	-0·350	-1·72
C	78	-1·675	-1·19
D	78	-0·915	-1·19
E	78	-0·026	-1·47
F	39	-0·405	-0·64
G	39	-0·470	-0·52
H	34	-0·507	-0·17
I	39	-0·000	+0·03

The sand cast alloys, which did not include A, not only did not grow under this treatment, but for the most part showed a progressive shrinkage. In the case of D, E, and I there was a momentary expansion as a result of the first heat or two heats, but it was followed by a contraction. In some cases the shrinkage reached a maximum value and then diminished somewhat. In others, as for example C, it progressed almost uninterruptedly through seventy-eight heats. In all cases the final result was a permanent shrinkage, which in six out of the eight alloys did not reach more than half 1 per cent.

It was observed that a progressive diminution in weight took place throughout, except in the case of alloy I, where it was succeeded by an increase after the twenty-ninth heat.

Alloys B to I of the chill cast series behaved similarly to those of the sand cast series, even although there was a permanent shrinkage in only two out of the eight alloys. Alloys B to E all showed a shrinkage at the sixty-seventh heat. The authors think that the apparent slight permanent expansions recorded from E to I in the summary are caused by the scale, which naturally forms more plentifully on the lower carbon members, and which tends to loosen itself from the bar, and thus give too high a reading.

The only alloy which showed a permanent growth of any magnitude was A, and even this showed a shrinkage after thirty-four heats. A permanent expansion was recorded at the thirty-eighth heat, and in the next fifty-two heats the bar grew slowly but steadily until, at the ninetieth heat, a growth of 6.88 per cent. was obtained. At a later stage of the research the explanation of this behaviour was found. For the present the authors desire to omit this alloy from their consideration of this series.

Broadly speaking, then, pure iron-carbon alloys, whether chill or sand cast does not matter, do not expand permanently after repeated heatings, but on the contrary shrink. The amount of shrinkage is so small that, from a practical standpoint, it is almost if not quite negligible. The results obtained at this stage may be said to have given the authors the solution of their practical problem, viz., an alloy whose volume shows no tendency to change appreciably after numerous heatings to about 900 degrees C. Such an alloy would be a white iron with about 3 per cent. of carbon and only small quantities of other constituents, of which for this purpose silicon is the most important. This alloy would shrink slightly on repeated heatings, but it would probably be not more than something of the order of 1 per cent. after one hundred heats. This type of shrinkage is usually ascribed to the gradual removal of contraction stresses set up in the originally cast metal. The loss of weight observed, which tends to diminish with decreasing carbon content, is caused by the gradual oxidation of carbon by the furnace gases which penetrate into the muffle, and, as later experiments showed with other alloys, into the bars themselves. The real is no doubt greater than the apparent loss, because there is probably a simultaneous absorption of oxygen, which is evidently the explanation of the increase in weight of alloy I.

When it was found that alloys A to I, whether cast in chill or sand moulds, were white irons, four more alloys were made, in which the carbon ranged from 4.6 to 3.0 per cent., and the silicon varied between 0.5 and 0.79 per cent. They also contained a considerable amount of manganese. They were cast in sand, the base of this series being a grey iron. The following is the complete analysis made:—

High Carbon Medium Silicon Series.

Alloy.	Percentage.				
	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
J	4.60	0.79	1.26	0.018	0.016
K	3.90	0.69	1.09	0.019	0.021
L	3.60	0.65	1.02	0.018	0.017
M	3.02	0.50	0.86	0.018	0.017

The fracture of J showed a grey iron, except for a mottled area near the centre. K and L were almost entirely white irons, and contained only small amounts of graphite. M was a white iron. Test bars were ground to size in the same way as those of the A to I chill series. They were heated sixty-eight times. These alloys grew steadily from the outset. Ultimate growth was reached in from fifty to sixty heats; it was greatest in J and least in L. The following table enables a comparison to be made:—

Alloy.	Percentage growth after			Ultimate growth.	Percentage change of weight.
	10 heats.	19 heats.	29 heats.		
J	3.48	8.02	11.26	12.65	+0.21
K	2.35	6.10	7.80	10.35	-0.74
L	2.24	5.15	6.68	8.70	-1.05

After reaching a maximum growth the bars showed a tendency to contract slightly. It will be observed that the bar with the least silicon shows the least growth, and that with the highest silicon the greatest growth. Alloy M behaved differently from the above trio, and in a manner which recalled that of A under similar conditions. It contracted during the first ten heats, but after the eleventh heat it showed a growth, and this increased until a maximum value, viz., 6.2 per cent., was obtained after fifty-eight heats. The test bar of M had been cut from a part near the gate end of the casting. In order to see whether the same behaviour would be shown by a bar cut from another part of the casting, the top of one of the risers was selected, *i.e.*, a part as far distant as possible from the other. This was subjected to similar heatings, and in this case the bar contracted up to the ninth heat. It was not measured after the tenth heat, but after the eleventh heat it was found to be expanding. The rate, however, was slower than in the case of M, and it was only after the fourteenth heat that the bar showed a growth as compared with the original size. The rate of growth remained slower, and the maximum growth, obtained after forty-seven heats, was only 2.54 per cent.

Apart from the difference in the amount of the ultimate growth, the fact of a contraction up to the ninth or tenth heat, followed by an expansion, was thus confirmed.

To account for this behaviour of alloys A and M, a hypothesis naturally suggested itself in view of the

two main facts hitherto established by the research. These facts were:—

1. All the alloys examined, which did not contain graphite or free carbon in some form, did not grow, but actually contracted to a greater or less extent (alloys B to I).

2. All the alloys examined, which contained graphite, grew (alloys PH, NIP, J, K, and L).

The natural hypothesis to account for the behaviour of A and M was to assume that these alloys, originally white irons, contracted as long as they remained white, but that after a time they deposited free carbon, probably as temper carbon, and that this, either directly or indirectly, caused their growth. This hypothesis was tested and the change from shrinkage to growth under repeated heatings in the case of alloys A and M was shown to coincide with the appearance of free carbon, probably temper carbon. Free carbon was in this way proved to be in some way an indispensable factor in the growth of cast iron under these conditions. This fact is of fundamental importance.

Some time before the previous experiments were concluded it had become evident that the influence of silicon must be thoroughly investigated. Of the alloys hitherto tested all those containing 0.65 per cent. of this element grew from the outset, the largest growth being obtained with the highest silicon. The next series of alloys was designed so as to contain a constant quantity of carbon, about 4 per cent., and ascending percentages of silicon from 1 to 6 by steps of 1. Manganese, sulphur, and phosphorus were to be kept as low as possible. The reason for this choice was as follows:—It was argued that the earlier members of the series would contain some "combined" carbon, and that the later would contain all their carbon in the "graphitic" condition; that by repeated heating, the former would tend to deposit their combined as "temper" carbon, and that if the "growth of cast-iron" was due to an expansion consequent on this chemical change, the earlier members should grow and the later ones should not. It was obvious that such a series would also test whether growth was proportional to the percentage of silicon.

IRON-CARBON-SILICON SERIES.

The analysis of the alloys designed to test more specifically the part played by silicon is as shown in Table VI.

It will be observed that the total carbon in the series is approximately constant, that alloys N and O contain about the same amount of combined carbon, that alloy P contains about half the quantity, and that the remaining alloys contain none at all. The silicon in O and R is 0.2 per cent. lower, in Q 0.2 per cent. higher than was desired. The remaining constituents are satisfactorily low and constant.

It is with this series that the authors have carried out most experiments, and from it they have derived the most information as to the cause or causes at work in the permanent expansion of cast irons after repeated heatings.

First Series of Experiments with Alloys N to S.

Test pieces, 6 in. by about 0.88 of an inch, were machined from the castings. They were not taken from similar positions throughout, but haphazard, some from the gate, others from a riser either near to or at some distance from the gate. When the growth of these alloys was investigated it quickly became evident that the position from which a test piece had been cut had a considerable influence on its rate of expansion. It was found that specimens taken from the gate end of the casting grew more rapidly than those taken from the top of a riser. The results obtained as to the behaviour of the six specimens are plotted in Fig. 1, the co-ordinates being percentage growth and number of heats. In this way the rate of growth is clearly seen. In the case of N, O, and P the curves are plotted from the data obtained. It will be observed that the growth is rapid at first, diminishes after about the seventh heat, and stops at the sixteenth heat.

TABLE VI.

Alloy.	Percentage.						
	Total Carbon.	Combined Carbon.	Graphite.	Silicon.	Manganese.	Sulphur.	Phosphorus.
N	3·98	0·64	3·34	1·07	0·25	0·010	0·013
O	3·98	0·68	3·30	1·79	0·23	0·010	0·013
P	3·79	0·30	3·49	2·96	0·25	0·010	0·012
Q	3·76	nil	3·76	4·20	0·27	0·010	0·013
R	3·79	nil	3·79	4·83	0·30	0·010	0·013
S	3·38	nil	3·38	6·14	0·30	0·010	0·013

In the case of Q and R curves are plotted in full lines from the data obtained up to the point at which cracks appeared, viz., the twelfth heat. Beyond this the direction of the curves can only be guessed, and this is indicated by dotted lines. Attention is directed to the fact that the initial rate of growth of P is much greater than that of Q or R, and that it is only surpassed by them after the twelfth and tenth heat respectively. The data for plotting a curve of

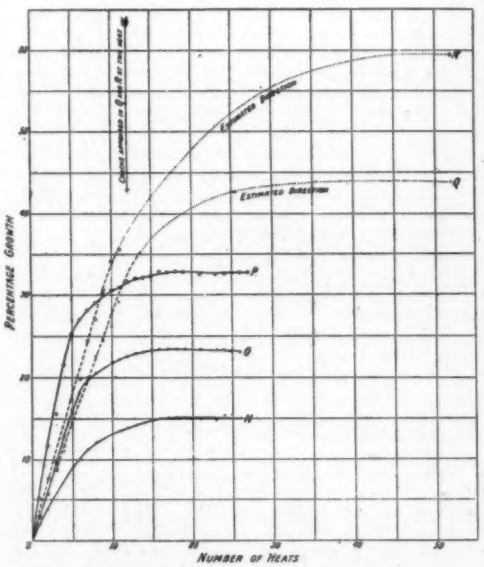


FIG. 1.—CURVES SHOWING RATE OF GROWTH OF ALLOYS N. TO S.

the rate of growth of S are insufficient. The appearance of the bars after maximum growth is reached is seen in the upper half of Fig. 3. To enable a comparison of the growth to be made, a bar of the original size is included on the left hand. It will be observed that N, O, and P have kept their cylindrical form in spite of a growth of 32.85 per cent. in the last case, and that Q, R, and S are increasingly distorted

under the heat treatment given. The following table summarises the results:—

Alloy.	Percentage Silicon.	Percentage Growth on Heating.
N	1.07	15.40
O	1.79	23.46
P	2.96	32.85
Q	4.20	43.9
R	4.83	59.5
S	6.14	63.0

It is quite clear from these tests that silicon is a most important constituent of cast iron from the standpoint of growth under repeated heatings. If the ultimate growths and percentages of silicon are plotted as co-ordinates, the curve in Fig. 2 is obtained, which shows that, broadly speaking, the growth is proportional to the percentage of silicon, although the value for R seems relatively higher than those of the other five alloys. The growths are far in excess of those that could be caused by the conversion of combined into free carbon. Alloy N contained originally 0.64 per cent. combined carbon, corresponding to 9.6 per cent.

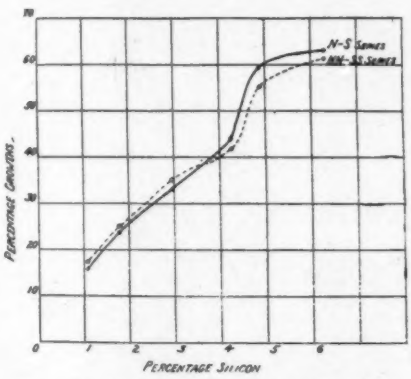


FIG. 2.—ALLOYS N. TO S. CURVES SHOWING RELATION BETWEEN PERCENTAGE GROWTH AND PERCENTAGE SILICON.

Fe_3C. The complete decomposition of this in accordance with

A would cause a growth of 0.61 per cent.
B " " 1.58 "

Either of these is inadequate to account for the 15.4 per cent. growth found. The same obviously holds even more strongly for alloys O and P.

The fact that the two alloys P and S, which had been cut from the gate, grew more rapidly than the remaining four, which had not, pointed to an agent which had hitherto been left out of consideration, viz., the gas contained in the original casting, and perhaps also the gases in contact with the test pieces in the muffle. The gate of a casting is, as a rule, more "open" and contains more gas than the risers, and the next step in the investigation consisted in testing bars which were, as far as possible, comparable with one another from the standpoint of their gas content. Accordingly another set of bars was machined, each test piece being taken from the top of a riser—that is, as far as possible from the gate. This series is indicated with double letters, except in the case of O, which is marked with a triple letter.

Double-Lettered Series, NN to SS. Volume Changes.

These samples grew under heat treatment, and reached approximately the same ultimate growth as did the corresponding members of the previous series, but the rate of growth was in all cases slower. Cracks did not develop in QQ and RR until after the eighteenth heat, as compared with twelve heats in the single-letter series. But the most marked difference was shown by SS, which did not develop cracks until after the eighteenth heat, whereas S cracked after the first heat. Further, although SS cracked extensively (see Fig. 3) before ultimate growth was reached, the cracks never became so large, nor was the specimen as much deformed. These results can be most simply explained by supposing that the castings contain their dissolved gas unevenly distributed, the gate containing the maximum and the top of a riser the minimum, and that the disruptive effects noticed in S were due to an excessive amount of dissolved gas.

It was further observed that the end of a sample nearest the gate always grew more rapidly during the earlier heats than the other end, but that ultimately the end farthest from the gate caught up and sometimes passed it. Table VII. illustrates this fact:—

TABLE VII.

Heat No.	Alloy OOO.		Alloy QQ.		Alloy RR.	
	Far.	Near.	Far.	Near.	Far.	Near.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
3	1·92	2·44	1·53	1·65	1·54	1·94
10	6·20	6·05	7·40	6·83	7·97	6·73
15	7·28	6·55	8·20	8·20	9·15	7·98

NOTE.—The words "far" and "near" refer to positions with reference to the gate.

The more rapid growth of the end nearest the gate is explicable on the above supposition, viz., as being due to a larger amount of dissolved gas. It was the fact that the other end ultimately caught up and sometimes passed it, which led the authors to attribute this to the action of gases in contact with the specimens in the muffle. This point is dealt with later.

From the two series of tests the authors draw the following conclusions:—

1. In a series of cast irons of approximately constant carbon the ultimate growth after repeated heatings is, broadly speaking, proportional to the silicon present. This relationship holds up to 6 per cent. of silicon.

2. The growth is far in excess of that which can be caused by the conversion of combined to free carbon, and is in fact much the largest in high-silicon alloys which contain no carbon combined with iron. (Alloys Q, R, and S.)

3. The behaviour of the alloys on repeated heating, and particularly of Q, R, and S, points to the view that two agencies are at work in their growth, viz.:—

(*a*) The internal pressure of gas which they contain in their original cast condition, and which is probably chiefly physical in its character.

(*b*) The effect of external gases in contact with the alloys during their heat treatment, and which is probably partly physical and partly chemical in its nature.

As regards 3 (*b*) considerable light has been thrown on the matter by a consideration of the changes of weight which accompany the changes of volume discussed above.

Series NN to SS.

This series increased in volume more slowly than the other. Its increase in weight was also less rapid. This is notably the case with QQ, RR, and SS, especially the last-named, where the rate of increase was almost uniform.

Table VIII. enables a comparison to be made between the final increases in weight obtained in the two series.

TABLE VIII.

Percentage Silicon.	Percentage Increase in Weight.	
	After Twenty-six Heats.	
1.07	N 0.65	NN 0.94
1.79	O 1.89	OOO 2.22
2.96	P 3.62	PP 4.03
	After Fifty-two Heats.	
4.20	Q 9.59	QQ 9.33
4.83	R 10.25	RR 10.30
6.14	S 13.20	SS 11.55

the other to decrease their weight. Later experiments showed that they absorb gases from the interior of the muffle, principally carbon dioxide, carbon monoxide, and nitrogen. The two first-named gases tend to oxidise the silicon and carbon in the alloys. The former process, of course, results in an increase, the latter in a decrease of weight.

The study of the changes of weight accompanying the growth of these alloys has shown: —

(*a*) A partial oxidation of carbon, which diminishes with increase of silicon and becomes *nil* at 6 per cent.

(*b*) A probably complete oxidation of the silicon, originally present as iron silicide, to a mixture of iron oxide and silica.

(*c*) A partial increase as iron uncombined with silicon. It is quite clear from a study of the curves of increase in volume and increase in weight that the two

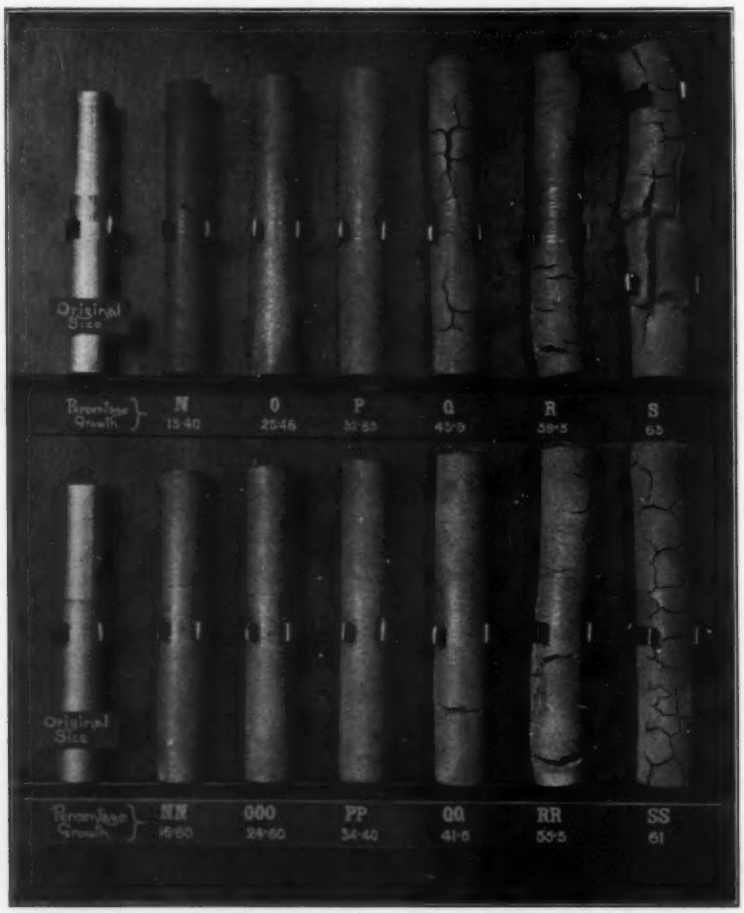


FIG. 3.—ALLOYS OF THE N. TO S. SERIES, AFTER REACHING THEIR ULTIMATE GROWTH.

It was observed that the increase in weight follows the same order as the increase in silicon, just as did the increase in volume. There are, however, complications in this case which probably do not affect the volume changes and make it more difficult to interpret the "increase in weight" curves.

During the heating and cooling of the alloys two causes are at work, one of which tends to increase and are closely related to one another, and that the growth of these alloys under heat treatment is bound up with a change in the chemical condition of the silicon and to some extent of the iron.

Microscopic Study of the Alloys.

A very large number of specimens were investigated in this part of the research, and time did not permit of

an exhaustive study of the changes of structure accompanying those of volume and weight in all cases. After detailing the particulars of the research the authors state that the comparison of the results of the two series of alloys treated serves to emphasise anew that free carbon, in the form either of graphite or temper carbon, is one of the essential factors in the growth of cast irons under heat treatment. The previous series of alloys (N to S), however, brought out equally clearly the fact that in a constant graphite series the growth is roughly proportional to the silicon present. It is clear, therefore, that both graphite and silicon are involved in these changes of volume after repeated heatings.

Investigation of the Influence of Gases on the Growth of Cast Irons.

The paper here gives full details and micrographs of the experiments, and summarising the results, the authors conclude that it may be said that there are alloys, *e.g.* S, whose growth in air is due entirely to oxidising gases penetrating their interior, and others, *e.g.* N, where this may not be the sole agent, but where originally dissolved gases contribute to some extent to the growth.

Time has not permitted of a completer study of this aspect of the growth of cast irons. Investigations are, however, still proceeding, and will, it is hoped, form the subject of a later paper.

Comparison with Mr. Outerbridge's Results.

While the experimental results obtained by Mr. Outerbridge and the authors are usually in general agreement in places where the same ground is traversed, it seems probable that his views as to the cause of the "growth" of cast irons after repeated heatings will require to be modified in the light of results obtained in the foregoing research.

1. His statement that "the increase of free carbon does not account in any way for the enlargement of the bar" was doubtless true of the grey iron with which he was experimenting; and holds for grey irons generally. But it is not true of white irons which become grey on heating, and expand in so doing. So far as existing data permit of an opinion being formed, this change is quite enough to account for the whole of the growth observed. (Alloys A and M.) The authors' experimental results with these two alloys are in disagreement with his opinion that "white iron in which nearly all of the carbon is in the combined form does not expand sufficiently to overcome the original shrinkage even after all of the combined carbon has been changed to graphite"; and conclusively show that it does.

2. Mr. Outerbridge states that his "enlarged bar (40.98 per cent.) weighed precisely the same as before treatment." The authors' have great difficulty in accepting this statement, which is at variance with their entire experience. His bar was heated in an iron pipe, the ends of which were stopped with clay, at a temperature of 800 degrees C.; that is, under conditions which permitted of the penetration of oxidising gases, and were thus very similar to those used by the authors. In not a single one of the numerous cases examined by them did the weight remain constant. Every grey iron increased in weight, and the growth has been shown to be connected with this increase in the most intimate manner.

3. The authors' results have shown that Mr. Outerbridge's conclusion that "the astonishing change in volume is a molecular and not a chemical one, thus substantiating my original theory of the mobility of cast iron," is incorrect in this unqualified form. Their experiments connect in a very intimate way the growth of grey irons with a chemical change in the condition of the iron silicide which is invariably present.

4. His statement that "the peculiar property of cast iron of increasing in bulk under the influence of heat is inherent in the metal, and has existed for all time," is also incorrect in this unqualified form. Alloy S is an exception. Its growth has been proved to be due entirely to the action of penetrating gases.

Summary.

The following section contains a summary of methods and results in the order in which they were obtained:—

1. The conditions under which the maximum growth of commercial cast irons is brought about by repeated heatings were determined. As a result a period of four hours at 900 degrees C. was chosen for the experiments.

2. It was shown that for growth to take place both heating and cooling are required. A given specimen grows no more under a seventeen hours' than a three hours' treatment.

3. Methods of measurement of temperature and volume changes were decided upon. For the former thermo-junctions and a direct-reading pyrometer were used; for the latter micrometer callipers reading to 0.0001 of an inch.

4. Test bars were heated in a cast-iron muffle protected from the direct action of the flame by another muffle of fireclay.

5. Three commercial cast irons were investigated. They grew at different rates and to different extents. After ninety-four heats they reached a constant volume. The growths varied between 35.21 and 37.50 per cent. An increase in weight was found in all cases.

6. The first step consisted in an attempt to correlate growth with chemical composition.

7. *Iron-carbon Series of Alloys Containing no Graphite.*—The carbon ranged between 4.03 and 0.15 per cent. Other constituents were low and constant. (Eight alloys, B to I.)

A. *Sand Cast Alloys.*—White irons. The final result after thirty-nine to seventy-eight heats was a permanent shrinkage in all cases, which in six out of eight cases was not more than 0.5 per cent. A diminution in weight was found in seven out of eight cases, which followed nearly the same order as the carbon.

B. *Chill Cast Alloys.*—White irons. The results were similar to those obtained with the sand cast alloys, although the permanent shrinkage was not so fully marked.

8. The results obtained under 7 have given the authors the solution of the practical problem, viz., the finding of an alloy whose volume remains constant even after repeated heatings at about 900 degrees C. Such an alloy would be a white iron with about 3 per cent. of carbon, and only small quantities of other constituents of which for this purpose silicon is the most important and should not exceed about 0.2 to 0.3 per cent.

9. *High Carbon Medium Silicon Series* (J, K, and L), *Containing Small Amounts of Graphite and* 0.5 *to* 0.8 *per cent. of Silicon.*—These alloys grew from the outset, and reached their maximum growth in fifty to sixty heats. The bar with the lowest silicon showed the smallest, that with the highest silicon the largest growth.

10. Two initially white irons, A and M, contracted for a certain number of heats and afterwards grew. It was shown that both these irons became grey on heating, and the change from shrinkage to growth was shown to coincide with the appearance of free carbon (temper carbon); and in the case of M as the

free carbon increased, so did the growth. Free carbon, whether graphite or temper, was thus proved to be an indispensable factor in the growth of cast iron under these conditions.

11. It was shown by calculation with existing data, which are, however, not very satisfactory, that the growths of A and M observed may be accounted for by an expansion consequent on the deposition of temper carbon in accordance with the equation—

$$\text{Iron carbide } (Fe_3C) = \text{iron } (3Fe) + \text{temper carbon } (C).$$

12. The influence of silicon was next tested.

Iron-carbon-silicon Series.—Alloys, N to S. Carbon, 3.4 to 3.98 per cent.; silicon, 1 to 6 per cent. in steps of 1 per cent. Other constituents low and constant. Growths of between 15 and 63 per cent. were found. It was shown that they were, broadly speaking, proportional to the silicon present and far in excess of what could be caused by the conversion of combined to free carbon. In fact, they were largest in the high-silicon alloys which contained no carbon combined with iron.

13. The bars tested in 12 had been machined at haphazard, some from the gate, others from risers in different positions. The rate of growth was shown to depend on the position. Bars cut from the gate grew more quickly than those cut from risers. That end of a bar nearer the gate grew more quickly than the other. The ends of some of the bars grew more quickly than the centres.

14. Bars cut from comparable positions were next tested (NN to SS series). They were all cut from the top of a riser. They grew more slowly than the N to S series, but ultimately reached about the same growths.

15. It was quite obvious from the behaviour of this series of alloys that *gases* played an important *rôle* in their growth.

16. The curves of rate of increase in weight were seen to be similar to those of growth, and established an intimate connection between the two.

17. The final increase in weight followed the same order as the percentages of silicon. It was shown to be the resultant of three processes. (*a*) A partial oxidation of carbon which diminished with increase of silicon and became *nil* at 6 per cent.; (*b*) a probably complete oxidation of silicon, originally present as the silicide of iron, to a mixture of iron oxide and silica; (*c*) a partial oxidation of iron uncombined with silicon.

18. The growth of the alloys, N to S, was thus shown to be bound up with a change in the chemical condition of the silicon.

19. The gradual penetration of gases into the alloys during growth was studied microscopically in P, and the structural changes recorded. Large amounts of gas are dissolved at certain stages. Graphite is displaced from its original position—the spaces left are oxidised—and numerous small holes are formed. The structure is revolutionised.

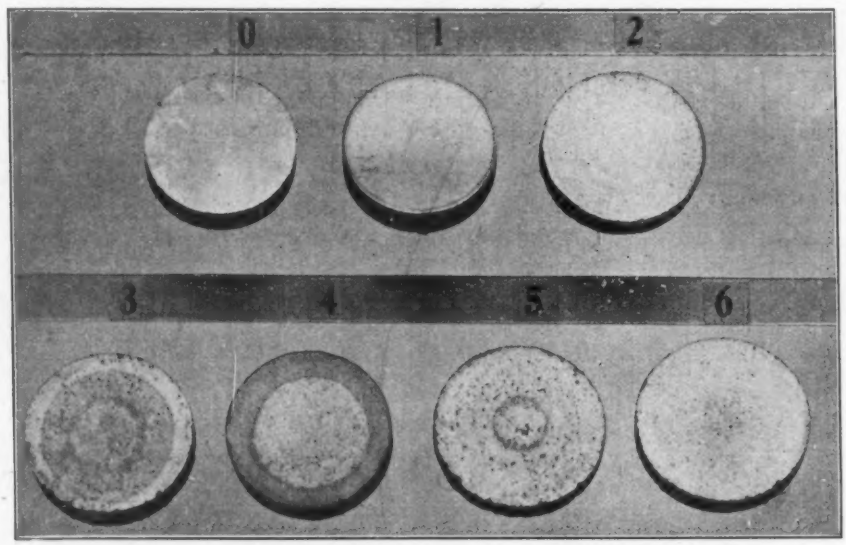


FIG. 4.—ETCHED SECTIONS OF ALLOY P AT VARIOUS STAGES OF GROWTH, ILLUSTRATING THE PENETRATION OF GASES AND THE DEVELOPMENT OF HOLES.
(0) Original casting. (1) After one heat. (2) After three heats. (3) After six heats. (4) After ten heats. (5) After fifteen heats. (6) After twenty-one heats.

20. *Iron-silicon Alloys.*—T, U, and V. Silicon, 0.65 to 2.71 per cent.—containing no graphite, were shown not to grow appreciably after repeated heatings.

21. The influence of gases on two members of the N to S series was studied. Alloy S, which grew 62 per cent. in a muffle, not only did not grow when heated in vacuo, but actually contracted slightly (0.04 per cent.). In doing so it gave up 1.11 times its volume of gas, which consisted of 87.5 per cent. hydrogen and 12.5 per cent. nitrogen. Another bar, after being heated in vacuo, until it had ceased evolving gas, was heated in a muffle and ultimately grew 67.7 per cent. It was thus shown that the growth of this alloy is entirely due to the penetration of gases, and that the gases it originally contains have no direct share in the growth. About 47 per cent. of the penetrating gases consist of oxides of,

carbon. They are responsible for the oxidation of the iron silicide which is so closely bound up with the growth of this alloy.

22. The more rapid growth of the ends than the rest of the bar is readily explained, as they expose more surface to the penetrating gases.

23. The more rapid growth of the end of the bar nearest the gate of the casting is connected with the fact that it contains more dissolved gas, but the cause of it is not as yet clear.

24. Alloy N, which grew 13.5 per cent. in a muffle, grew 11.1 per cent. when heated to constant volume in vacuo. It gave up 1.17 times its volume of gas, which was almost exclusively hydrogen (98.5 per cent.). As regards growth in vacuo this alloy thus furnished a complete contrast to S. The explanation suggested is that this iron, which is very close-grained, does not give up all its gas on heating. Some of it remains permanently imprisoned. Its co-efficient of expansion being about 400 times that of the iron when it is liberated on heating, *e.g.*, at the surface of contact between the iron and the graphite plates, the pressure will be sufficient to produce a permanent expansion.

25. N appears to be an alloy whose dissolved gases are capable of causing a large growth, at any rate where external gases are removed.

26. The growth of N in a muffle is probably caused by the combined effect of both originally dissolved hydrogen and the penetrating oxides of carbon.

27. The research has thus disclosed, among the grey irons, alloys, *e.g.*, S, whose growth in air on heating is entirely due to oxidising gases penetrating their interior, and also alloys, N, where this may not be the sole agent, but where originally dissolved gases contribute to some extent to the growth.

28. The authors' results are compared with those of Mr. Outerbridge.

The Agencies at Work in the Growth of Grey Cast Irons on Repeated Heating.

Although the foregoing research has not settled all the issues it has raised, it appears possible to form a mental picture of the mechanism of the growth of annealing ovens, and other cast-iron vessels, in ordinary practice. These ovens are grey irons. They contain graphite and silicon, whose presence has been shown to be so intimately connected with growth. They also contain manganese, sulphur, and phosphorus, whose influence has not been investigated, and must therefore be left out of account. They contain some dissolved gases, and they are exposed in practice to the direct action of flame gases, the influence of both of which has been carefully studied. They consist of four main structural constituents, which may almost be considered as three. (1) A solid solution of iron silicide in iron and manganese; (2) graphite; (3) some combined carbon—pearlite; (4) phosphide eutectic. With repeated heating 3 tends to pass into 2. Only 1 and 2 will be considered.

It has been shown that after the first heating gases have penetrated to a certain depth (Fig. 4), and also that seventeen hours' heating produces no more growth than three. A certain time is, of course, required, depending on the size of the oven and the rate of supply of heat for the oven, to acquire a steady temperature, and the volume corresponding to this. The authors' view is that, although the gases penetrate to a certain depth during this period, possibly along slits existing between the graphite plates and the solid solution of silicide in iron, and through holes which exist here and there, yet they are not actually absorbed by the solid solution until the oven is cooling. During this absorption the oxides of carbon oxidise the iron silicide, in the first instance, at the boundaries of the crystals. This reaction is accompanied by growth and incipient disintegration. Minute cracks are formed. There may be a series of minute explosions, owing to the reaction between the dissolved hydrogen and the penetrating oxides of carbon. The mechanically weak graphite may be disintegrated and forced into holes originally existing in the metal. Nitrogen enters along with the oxides of carbon, and is absorbed to some extent (see gas analyses). The net result is a slight growth of the oven by the time it has cooled to the ordinary temperature.

When the oven is next heated, the furnace gases penetrate a little farther, owing to the fresh avenues opened up by the reactions just described. On cooling these reactions are repeated, and in this way more of the iron is disintegrated, and a further growth takes place. Simultaneously, if the iron is close-grained, like alloy N, hydrogen and nitrogen are liberated in the interior at the boundaries between the solid solution and the graphite. Their co-efficient of expansion is so much greater than that of the solids that they exert a considerable pressure, with the result that the mechanically weak graphite is disintegrated, and appears to collect in the holes of the casting. Where the boundary between two holes consists of graphite, it is destroyed by this action, and the two holes become one.

As the heats progress these changes continue. After each heat the external gases have penetrated a little farther (Fig. 4). Finally, they work their way right through the oven, the rate depending on its chemical composition, physical texture, etc. When this condition is reached (Fig. 4, No. 6), the oven has grown to its full extent. Some of the graphite has been burnt off, all the silicide of iron has been oxidised, probably to a mixture of iron oxide and silica, and some iron has been oxidised as well. The main cause of growth is the disintegration of the material caused by the oxidation of the iron silicide. In close-grained irons the pressure of dissolved gases also contributes to the growth. At the conclusion of the process the structure has been revolutionised; the oven has lost the properties of cast iron. It has no mechanical strength, and can be sawn like a piece of chalk.

The authors have no hesitation in recommending that white irons should be tried for annealing ovens instead of grey. The most suitable composition appears to be an iron with about 3 per cent. of carbon and as few impurities as possible. Of these silicon is the most important, and should not exceed 0.2 to 0.3 per cent. This iron would probably shrink slightly on repeated heating. The reason why an upper limit of 3 per cent. of carbon is suggested is that white irons higher in carbon will tend to deposit temper carbon. Where this is the case, the material will begin to grow. Even so, however, the growth will never be as much as in a grey iron. It is possible that an oven constructed of white iron may prove to be unsuitable, because it may crack on heating. Should this difficulty arise, it may perhaps be overcome by modifying the design.

The authors acknowledge with much pleasure the ready assistance given by Mr. C. A. Edwards, the demonstrator in the department, with the analytical and photographic work.

The business of the Electromotor and Dynamo Company, 15, Gray's Inn Road, W.C., has been taken over by Messrs. J. & H. Grevener, who are now in a position to supply motor generators, transformers, and controllers of the highest quality, as well as their well-known Arcoflame lamps.

A Regeneratively Heated Crucible Furnace.*

By W. M. Carr.

In presenting a furnace of this type advantage is taken of a principle of fuel economy that is extensively applied to steel melting. The principle is heat conservation by regeneration through storing up and usefully extracting energy from what would otherwise be waste or lost heat values. It is rather surprising that the same principle is not fully considered or recognised in other metal melting industries such as those dealing with pig-iron, copper, brass, bronzes, and various alloys, both ferrous and non-ferrous. With a few exceptions such metals are melted and refined in direct-fired furnaces, distinct from regenerative or recuperative furnaces. By direct firing is meant air or reverberatory furnaces with gaseous or solid fuel, or crucible furnaces fired with solid fuel surrounding the crucible or employing gaseous or liquid fuel such as oil, crude or distillate.

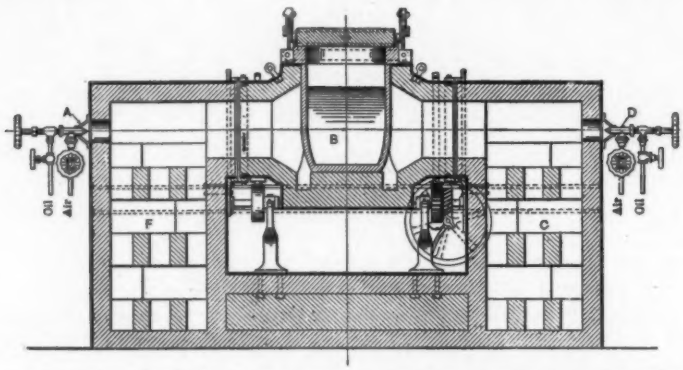


FIG. 1.—SECTIONAL ELEVATION OF A REGENERATIVELY HEATED CRUCIBLE FURNACE.

In furnaces of the types considered the burning fuel and its products of combustion have a brief contact with the material to be heated, giving up but a very small quantity of calorific energy and finally passing to the atmosphere with the greater part of the heat values going to waste. Little or no attempt is ordinarily made to utilise the heat in the products of combustion after they have given up part of their heat in melting or maintaining at a given temperature any of the metals above mentioned.

Air or reverberatory and crucible furnaces show a very low fuel efficiency. In the latter methods of melting the use of liquid fuel results in a greater economy than can be attained with solid fuel where the former may be purchased at a reasonable price, but the gain is not so pronounced as it might be if different means were employed to prevent the passage to the stack of most of the available heat.

Possibly the reason that direct-fired furnaces are more common for the purposes under consideration, is that they have been in times past less costly to instal than a regenerative or recuperative furnace, since furnaces of the latter types usually require gaseous fuel made from bituminous coal in gas-producers involving considerable expense in first cost as against a direct-fired furnace and stack only. Recent developments in regenerative furnace designs using fuel oil have changed conditions, dispensing with an expensive and troublesome gas-producer installation. Considerable alterations can be made in the design of regenerative furnaces laid down to use liquid fuel so that the first cost of erection is very little greater than a direct-fired furnace.

In regenerative furnaces fired with producer gas it is necessary to have four regenerator chambers per furnace, making the cost of installation quite heavy, representing approximately two-thirds the cost of the furnace body. On the other hand, where oil can be used the number of regenerator chambers is reduced to two. The use of oil as fuel also permits a decided decrease in the size of the furnace body of a given capacity far beyond any possibility with producer gas as fuel, thus greatly cheapening the cost of construction and offering a means of applying regenerative methods on a very small scale heretofore precluded by producer gas-firing. This brings within the reach of moderate expenditures the economical advantages of regeneration.

Concerning the matter of economy, regenerative furnaces operate with efficiencies of fuel values between 30 and 50 per cent. of available heat, besides giving higher temperatures than any type of furnace used in remelting processes and greater speed in operation.

Applying Regenerative Principles.

By referring to the illustration given herewith and the explanations following, the regenerative principle may be readily understood. In Fig. 1 there is shown a view in elevation of the type of furnace herein considered with the crucible chamber arranged to tilt. The operation is as follows:—Beginning at the left, the oil flame from the burner A is ignited and passes around the sides of the crucible B, then into the regenerator chamber C, giving up its waste heat to the checker bricks, pass-

* "Castings," April, 1909.

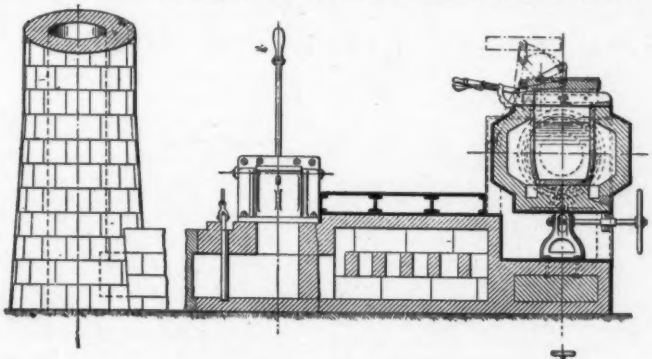
ing through the reversing valve and finally to the stack. But before reaching the reversing valve shown at the junction of the stack connection and checker chambers in Fig. 3, the temperature of the waste gas will have dropped several hundred degrees.

After an interval of about twenty minutes the oil burner A at the left-hand side is shut off and the burning oil started from the burner D at the right-hand side. The air necessary to support the combustion of the burning oil is, by stack draft, drawn through the air inlet on the right-hand end

By regenerative firing with the conservation of heat values there is effected a great step in advance over direct firing. In other words, the waste heat of the latter method is not utilised, while in the former the greatest possible fuel economy is secured.

The illustrations are more or less diagrammatical, and refer to an invention on which a patent is pending. The furnace is intended for the melting of refractory metals required in quantities of 1,000 lbs. or less at a time, for instance, such metals as nickel, manganese, and such alloys as ferro-manganese, ferro-chromium, ferro-vanadium, etc. It

FIG. 2.—SECTION THROUGH ONE OF THE REGENERATIVE CHAMBERS.



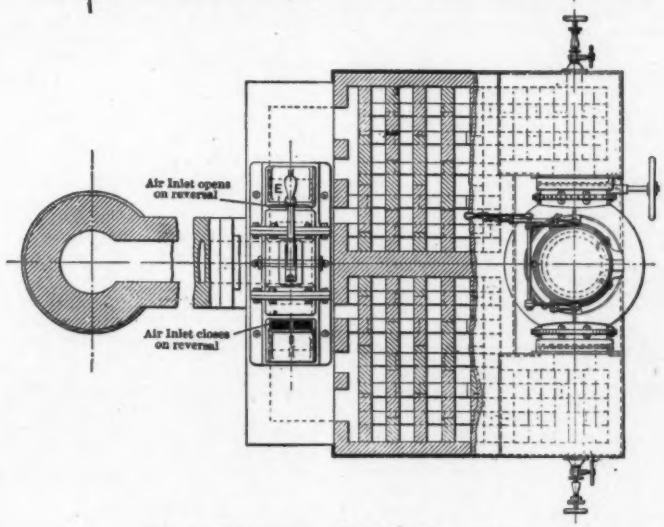


FIG. 3.—SECTIONAL PLAN OF FURNACE.

of the reversing valve, at E, Fig. 3, and passing through numerous flues and passages of the right-hand set of checkers C, in its course absorbs the heat radiated from them, this heat having been previously imparted by the outgoing products of combustion. By the time that the air reaches the burning oil it has been elevated to a very high temperature, and that temperature is added to that of the burning fuel. The products of combustion in this instance are passed through the left-hand set of checkers F, Fig. 1, repeating the operation as described in the beginning. By repeated alternations or reversals the temperatures are gradually increased so that it becomes easy to melt the most refractory commercial metals,

can be used for the lower melting-point metals, and the advantage to them would be a lower fuel cost than any direct-fired furnace. The furnace as designed will not allow the waste heat, flame, or products of combustion to come in contact with the metal within the crucible. The oil is atomised by low-pressure air, and since it burns with regeneratively heated air combustion is complete, and absolutely noiseless. No waste heat escapes into the shop.

Manipulation of Crucibles.

The crucible can be lifted out with tongs if desired or the furnace may be of the tilting type without lifting out the crucible, as shown in the illustrations.

This principle of regenerative firing is applicable not only to the melting of crucible steel and other refractory materials, but also to the melting of brass, bronze, and other alloys. When the furnaces are properly run, the work of the crucibles should be no more severe than with ordinary coal-fired crucible furnaces, and the fuel economy would be much greater. The temperature would be under control, and the working of the furnace much cleaner and better than in the case of the firing with coal or coke.

The simple matter of the elimination of the nuisance of having to remove ashes would be an important feature. In the case of a long furnace arranged for handling a number of crucibles, it would be possible to place almost twice the number of crucibles in a given space when compared with ordinary coke-fired furnaces. Then, too, as the heat control would be better, the melting would be more rapid, thus still further increasing the output of the furnace. Smelters and others engaged in the melting of large quantities of metal to be cast into ingots should find this class of melting equipment particularly advantageous.

The Making of Patterns for Cast Gears.

By E. L. M.

Although the moulds for cast gears are made on the gear-wheel moulding machine, there are still a great many, principally small sizes, which are moulded from complete patterns. This is often the case when castings are made by steel founders for another firm which only possesses an iron foundry. The complete patterns are made and supplied by the steel-founder's customer and returned to him after the required castings are produced. The making of wooden patterns for gear wheels is a long and tedious job, and requires great care in order that the shape of the teeth be correct. For these reasons the patterns are expensive to make.

There are various methods of forming the teeth, depending a good deal upon the ideas of the foreman pattern-maker. It is obvious that some form of jig or template is necessary, so that all the teeth can

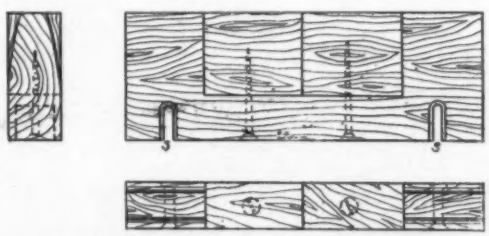


FIG. 1.—FIXTURE FOR HOLDING THE TEETH DURING SHAPING.

be made of exactly the same shape and dimensions. Again, as there are sometimes as many as 80 teeth on a wheel, time will be saved if two or three can be formed at the same time.

The following method, which has been used in a small shop for many years, is very efficient, and where special machines are not available, is probably the best that can be devised.

The nave, or hub, arms, and rim are first made in the usual manner. Blocks of wood, equal in number to the number of teeth are then made to the following sizes:—The ends are trimmed up to the length of tooth; breadth equal to the greatest width of tooth plus an allowance for shaping; height equal to the height of tooth plus an allowance for shaping.

The next step is to make a fixture for holding the teeth while being shaped. This fixture also serves as a template. A piece of hard wood, preferably of a colour which contrasts with the colour of the wood of which the teeth are being made, is carefully shaped along one edge to represent a very long tooth of the required shape, the length being from four to five times the length of a single tooth. A portion is then cut out, as shown in Fig. 1, so that two large, or three small, teeth can be inserted. The depth of this gap must be such that the top of the teeth blocks are flush with the tops of the end pieces

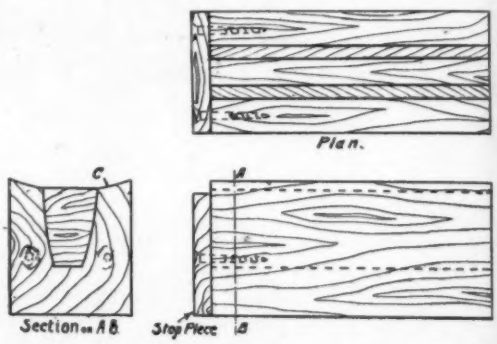


FIG. 2.—JIG AND TEMPLATE FOR SHAPING BASES OF THE TEETH.

or templates. Slots S, S, are made for screws which hold the fixture, which is now ready for use, to the bench. Two or three blocks, as the case may be, are now fitted fairly tightly between the end pieces and screwed in position from the bottom, as shown; the fixture is fastened to the bench and the teeth are shaped on each side in turn by means of a small plane. The difference in colour of the woods is useful here, for by watching the shavings it can be seen when too much is being removed, although it is not safe to go as far as this.

When all the teeth are shaped on their sides, the bases have to be curved to suit the curvature of the rim of the wheel. The easiest and safest way of doing this correctly, if the number of teeth warrant it, is to make a jig and template as shown in Fig. 2, which is held in the vice when being used. The groove is cut out to the exact size of the tooth, and the required curvature made which is shown exaggerated in the sketch at C. The teeth are placed in the groove, in which they should fit well, and their root surfaces curved with plane or gouge until the template surface is reached. The teeth are then glued and screwed in position on the rim and the roots filleted, either wood or putty being used for this purpose.

Staff Organisation in Large Manufacturing Plants.

By W. H. A. Robertson.

Readers of the technical papers have been recently more or less surfeited with descriptions of cost systems and commercial routine. Such articles indicate a progress on the commercial side that has been necessitated by the keen competition nowadays in all branches of industries. To all manufacturers who aim at efficiency it is of supreme importance to be able to analyse the cost of production of the commodities they make, and to them such articles appeal strongly.

The object of the writer is to point out the inefficiencies that are so much in evidence in large staffs, due to indefiniteness of authority, and to the overlapping of duties. It will be admitted that however well arranged a works' system may be, the whole will be rendered inefficient by a bad staff organisation. A works in which authorities (by which is meant heads of departments) overlap in their authority is without question the most inefficient arrangement possible, and must of necessity tell upon the profits of a concern. The aim of a large works should be to get the greatest amount of work out of each of its employés; the head of a department should therefore be responsible for the amount of important work that he is paid for, and his working energies should be given every scope to do more than he is expected to, to work on an overload if possible, but *not* for always, and *not* in a direction which is controlled by another head. By thus making men responsible for their own departments, and giving them encouragement and opportunities to advance in their own line, is a successful concern built up. Misunderstanding and bad feeling are apt to be engendered between heads if any overlapping of authority occurs.

In this country there is not perhaps so much of the kind of independent spirit of which America boasts. There they tell a story of a foreman who instructed his men to throw out of the window anyone who countermanded his orders to them; unfortunately the first man to transgress was the president of the company, who duly went through the window. The story that the president recognised his fault, and raised the wages of the foreman and workmen, has a truly Yankee flavour. But, without proceeding to such lengths in "independent spirit," there is little doubt that if heads of departments were given more scope and authority and made exclusively responsible for the work of their department, an enormous increase in useful work would be gained.

As an illustration of the writer's contention the organisation of a large rolling mill plant will be considered. The diagrammatic sketch herewith shows the relation of one department to another, and each division will be treated separately.

Board of Directors.—This meets at stated intervals to sanction the expenditure of money, additions to plant, and to decide the broad policy of the concern.

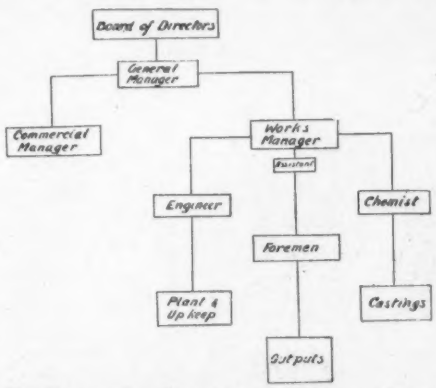
General Manager.—This official is responsible for the carrying out of the policy as laid down by the board of directors; he should have power to decide expenditure up to a certain amount at his own discretion. A man who is really earning his money in such a position has no time to go much into details; these should be thrashed out in the respective departments. With regard to works' plant he should be entirely guided by the opinion of the works' manager, who is responsible to him for the cost of production.

The Works' Manager is responsible to the general manager for the whole plant, delivery of orders, cost of production, etc. If the works are of such a size as to necessitate an assistant works' manager, his duties will be in connection with the detail work.

The Engineer should be responsible to the works' manager for the upkeep of the plant, and for the installation and design of all new works; he should deal with the correspondence, and order materials and fuel, stores, etc., in connection with plant upkeep.

The Chemist or Metallurgist should be responsible for all analyses, and should be in control of the casting shops. He is responsible to the works' manager.

A staff being thus arranged, the heads should be picked from men who are to be trusted, and they should have entire charge of their respective departments. It is quite a fatal thing for, say, the works' manager to try to find out what is wrong



DIAGRAMMATIC SKETCH ILLUSTRATING STAFF ORGANISATION IN LARGE MANUFACTURING PLANTS.

with the engineer's department. What becomes of his own work while he is investigating? Being in a highly-paid position all his time is required in carrying out his own work. The only reasonable and fair way is to dismiss a head who is not satisfactory. Having therefore a satisfactory staff, each at the head of his own department, and each working for the good of his firm and incidentally his own reputation, all should be well.

Now, although keeping each department separate is advocated, it is necessary for consultations to take place to discuss improvements, new methods, etc., and for such a purpose the general and works' managers, the engineer, and the chemist, should meet at certain intervals. A minute-book should be kept of these meetings, duly indexed and filed, for reference at any future date. If at any time decisions are made either by the Board, or managers, or heads of departments, definite written instructions should be given, and nothing left in the shape of vague and varied ideas.

Jolt-Ramming Moulding Machines and Foundry Methods.

At a meeting of the Philadelphia Foundrymen's Association, held on October 6, a paper on "Jolt Ramming Moulding Machines and Foundry Methods Involved," was presented by Mr. E. H. Mumford, of the E. H. Mumford Company, Philadelphia, manufacturers of foundry moulding machines. The following is an abstract of the paper:—

It is now quite 20 years since jolt-ramming machines, then cam-lifted and dropped on a rigid anvil operating on a small type flask, were used exclusively for ramming such work as wagon axle boxes and pipe balls. Gradually the application of pneumatic lifting plungers broadened out through the application of the method to larger and larger work, until to-day we have pneumatic jolt-ramming machines in successful service with lifting capacities from 10 to 15 tons, and tables 6 ft. by 9 ft., or even larger.

The method of ramming sand in jolt-ramming operations has the same effect as the old method of squeezing or press ramming by which the separate particles of silica or quartz, more or less thoroughly coated with the bonding element of alumina or clay, are dropped into closer compact amounting to a compression of 25 to 50 per cent. in volume, and through their closer association are stuck together by their clay jackets, thus constituting a more or less firmer body of rammed sand. Sand was rammed by impact even before it was rammed by pressure. In the throwing of sand into the deep pockets a grate bar was used long years before moulding machines were, and later we have had what are known as gravity machines, which drop compacted bats of green sand from an elevation, which in falling amalgamate with the sand already fallen to form a rammed mould.

The various processes of securing impact between the particles of green sand and so ramming them are, in fact, embodied in the jolt-ramming operation with the advantage that the sand which is to be rammed is placed in proper position, with the facing next to the pattern, gaggered and secured as desired, and, with the flask full, and with evenly distributed pressure, is then rammed by impact of the separate particles, upon one another through the succeeding blows of the machine table upon its anvil with the mould upon it. The action is not a uniform or a simultaneous one, but rather a progressive one, and it should be realised that one law applies in relation to all jolting machines, namely, that the effect of the impact as felt at the table of the machine varies directly as the height and inversely as the depression of the anvil under the blow.

This amount of compacting force represents the limit that can be secured with any given machine, and as every part of the horizontal pattern or joint surface shares this principle, it is probable that the first layers of sand immediately in compact with these surfaces, are rammed to a miximum hardness at the very first blow. What is true of the machine under the depression of the anvil at each blow is true of each grain or layer of sand as it comes to rest on the sand below it, and the sand in the upper regions of the mould—that is, where it is most remote from the pattern or joint surfaces—is but little rammed by the first impact, but gradually hardens in the lower strata and builds back on the upper layers of the sand until the entire mould is sufficiently rammed. The amount of lateral dispersion, such as will allow the sand to adhere to the sides of the flasks and bars slightly tapering, varies with the quality of the sand, and it is noticeable that sand as used for deep sand holes for steel castings acts better in this way by reason of its lesser friction among its particles, so that its movements down the sides of bars and flasks and into under-cuts are better than ordinary green sand. It is preferable to use bars of such a shape that the sand will flow of its own accord in its advance down the sides of the bars without leaving them, so that when the mould is rammed the sand, which has run down the sides of the wedge-shaped bar, will be found compacted under their relative sharp edges and still adhering to their sides.

It will be evident from the consideration of the above-named conditions, involving stability and firmness of surfaces, that vibration of all surfaces is to be avoided, and it is this vibration of flasks, bars, stripping plates and patterns which more than anything else has militated against the use of the well-known types of hand-rammed stripping plate machines upon the tables of jolt-ramming machines.

Jolt-ramming machines practically eliminate the operation of ramming as a time element. Even the heaviest moulds placed upon them are completely and almost perfectly rammed, and it is becoming a problem how best to take advantage of the greater economies of jolt-ramming machines, in view of the fact that it is almost impracticable with existing foundry appliances to transport the moulds to and from the machines and finish them on the floor fast enough to make complete use of the machine.

The travelling crane is an ideal instrument for the transportation of these moulds, but if the travelling crane is made to do the work of transportation which could as well be performed by a surface car, it is soon discovered that its proper function of lifting and lowering is sacrificed to getting it hither and thither over the foundry floor, often interfering with other cranes on the same runway. I make this suggestion, which seems to me the best way to reduce crane service and facilitate what is mainly transportation, so getting the best results from jolt-ramming. Assume that the machine is stationed at a point on a longitudinal foundry track, upon which a number of cars which can pass at turntables or otherwise are operated. Locate this track at one side of the heavy work floor. Lay rails at suitable intervals in the floor, running at right angles to the longitudinal track and upon the platform of a car running on this track and serving as a transfer car, fix tracks running across the bottom, flush with and in the same direction as those running athwart the shop. The moulds would then be set upon secondary cars on these tracks for ramming at any desired point on the floor, and then moved across to the transfer car and by it carried to a jib crane serving the moulding machine, by which the prepared mould is set upon the table of the machine. In a few seconds it is rammed and is immediately set upon the car which brought it. It is then returned over the route it travelled before to its original station on the floor. In this way large moulds may be rammed on a machine at one station and stored preparatory to pouring on the main floor of the foundry.

The British Foundrymen's Association.

Sheffield District Branch.

The first general meeting of the session was held at the University, Sheffield, on October 9. Mr. Percy Longmuir, B.Met., was installed as President of the Branch, and his inaugural address illustrated the unquestionable suitability of the choice.

Mr. Geo. Addy, M.I.Mech.E., and Mr. Tom Firth were elected Vice-Presidents; Mr. J. G. Crowther and Mr. R. W. Kemlo, Auditors. The Council were elected as follows:—Messrs. W. F. Bagnall, H. Bagnall, J. H. Breakey, W. H. Hatfield, E. Houghton (Chesterfield), W. H. Mainwaring (Sheepbridge), W. J. Peach (Sheepbridge), S. G. Smith (Staveley), R. Harris (Stockbridge), L. Redmayne, W. Morris (Butterley), and F. Gandy (Staveley).

Mr. Thos. Swinden, B.Met., of Sheffield, was elected Secretary and Treasurer.

The retiring President, Mr. H. Pilkington, M.Inst.C.E., was warmly thanked for his services, and more particularly for pioneering the movement in this part of the country. The Branch is now the second largest in point of numbers, and rivals Birmingham in point of influence.

Presidential Address.

Mr. Percy Longmuir addressed the members as follows:—

In speaking for the first time as President of this Branch, I wish to express my appreciation of the honour you have conferred upon me. Your Past-President has set a very high standard, and it will be no easy task to live up to his ideals. In an address of this character, the traditional custom is to give an historical survey of the field covered by the Association, but it may be well to depart from orthodox custom and, following Mr. Pilkington's example, give an address which may be discussed later.

Turning to some immediate aspects of general foundry practice, we have to admit that from its commercial side the industry is not in a healthy position. In stating that more orders and better prices are wanted one simply echoes a very prevalent opinion, and we all hope that these features will be realised in the early future. Times of quiet give good opportunities for setting the house in order; little troubles that have given rise to worries in times of pressure may then be investigated and solutions found. Methods may be studied and plant overhauled in readiness for the revival of trade. How many foundries take advantage of the leisure offered in times of depression to conduct this overhaul? It is wiser not to attempt an answer to this question, but to state in general terms that retrenchment in slack times is not necessarily economical in the long run.

The writer, as an individual, recognises that thrift may be carried to a vice if its outlook is narrowed down to immediate prospects, or orders in hand. True thrift will keep one eye on the immediate present and another on the future. A wise expenditure of capital and brain in periods of depression will often lead to good returns in periods of activity. Intelligent anticipation is, therefore, one of the prime essentials in those responsible for the management of an industry.

It is often said that spectators see most of the game; speaking with some knowledge of foundry practice, but not directly connected with any foundry, the writer would offer the following comments from the point of view of an unbiassed spectator. From the purely commercial side the foundry industry is not in the position it should be, but this phase will pass. From other points of view the industry is in a really good position, especially when judged by the quality of the work produced. One noteworthy feature is the ability of the British moulder, and the facility with which a man of average training can turn from light to heavy, and from iron to steel or brass moulding is really remarkable. The quality and type of castings produced in Sheffield, Manchester, and on the Clyde side, taking only three districts, is sufficient evidence of the skill available. The first impression is, therefore, that of high quality in the product, and skill in the makers of the product.

But we cannot stay here. Foundries are, of course, established to produce good castings, some of them are established to earn profits, and a study of profit-earning will show very erratic results in foundries of apparently similar equipment and engaged on similar types of work. Many reasons have been advanced for this variation, and the remedies suggested include technical education, scientific control, up-to-date methods, modernisation, etc. These remedies contain much that is good, but if adopted individually or collectively will *not* necessarily convert an adverse balance into a good one. Foundry management is largely a personal question and one of the first essentials lies in the level-headed control—in other words, common-sense based on actual foundry experience. A second essential lies in intelligent anticipation of future requirements. To some extent these include acquaintance with what is actually being done at the moment. Yet, taking one side only, how many foundries can give the exact cost of any given type of castings during production? To-day, estimating is largely based on guess-work.

The usual method of estimating the labour cost of castings is to divide the total labour charges, as shown in the wages book, by the output of the foundry, and so obtain a cost factor per ton or per cwt. This method is only satisfactory when the work produced is of a uniform and unvarying character. When the methods of moulding include green sand, dry sand and loam, with possibly plate and machine moulding, it is obvious that the plan of dividing total labour cost by total output can only yield an average cost factor. For direct guidance averages are useless, and it is evident that the good work of one section may be absorbed by a non-profitable section. Assuming the profit made by the former to be such as when distributed over the whole will show fair working, then the backwardness of the latter may escape detection for a considerable period. A detailed analysis of costs is essential and, where adopted, has fully proved its worth.

Another factor not meeting its just recognition is the value of output. Professor MacWilliam and the writer have noted this in "General Foundry Practice," and have there shown that the capital invested in a foundry demands a certain return. This return may be conveniently regarded as the production of a certain weight of castings each

week, such a weight being necessary to cover standing charges. Obviously, if this weight is not reached, no matter how low the labour cost of production may be, the foundry will be working at a loss. These remarks have arisen from recent experience in regard to estimates submitted for a series of very intricate castings. Twelve British firms quoted for these castings; no two of the quotations were alike, and from lowest to highest represented a very considerable range. Three Continental firms tendered, and the three quotations were almost identical. Curiously, the Continental price was just midway between the lowest and highest British tender. These three firms have no agreement as to price, and the only inference is that they had each systematised their methods of quoting by accurate cost analyses. We are often told to copy American plant and Continental methods of education. In the writer's opinion mere copying never leads to good results, but ignoring this for a moment we are compelled to ask if the oft-repeated advice has any point. It would seem that neither plant nor education, but business methods should be studied, and foremost in this commercial aspect is the question of accurate costing and intelligent estimating.

Turning to the more technical side, we sometimes note that a well-managed foundry, with no new equipment and very little aid from science, will give better commercial results than an up-to-date foundry assisted by all the scientific aids obtainable. Why should this be? The answer undoubtedly lies in the fact that all depends on the man behind the machine. Science, education, and practical skill are worse than wasted unless intelligently applied. Ill-managed modern facilities will never compete with well-managed old equipment. The crying need of to-day is not so much more education as an intelligent use of that we already possess. Large reserves of practical skill and science are available, and with all the emphasis possible I say let us use these supplies instead of repeating the parrot cry of "More technical education," copied from our Continental friends. A full recognition of existing facilities will lead to progress, and point the way to improvement in methods. Advancing step by step on the lines of experience and originating, is better than merely copying, whether applied to plant or method.

So much for the personal side; its importance cannot be over-estimated, but leaving the matter here we may turn for a few moments to some special aspects of founding. Taking the steel foundry first, it is generally recognised that the influence of composition so far as carbon and ordinary elements are concerned, has been fairly well worked out. Annealing, within ordinary limits, has been fairly well studied. Points of special moment lie in the investigation of the influence of special elements, a field almost uncultivated except in certain special cases, such as tramway and electrical castings. A point of real interest lies in the comparison of cast and forged steels. As an example, we may quote one casting containing 0.28 per cent. carbon, which gave the following tensile values:—

MS	E%	RA%
28.0	33.5	45.6

Such a result rivals that of a forged steel, and the steel will also bend double. Yet under alternating stress the forged steel will give ten to twenty times the life of the cast. We have therefore to recognise that though by certain treatment steel castings of remarkable properties can be obtained, they cannot compete with the forged material so far as working stresses are concerned. In the cast-iron foundry more information is required in reference to the effect of condition, especially in regard to the influences at work during production, remelting, and whilst cooling down in the mould. Here again a field is offered for studies in after-treatment. Mr. Pilkington has done valuable work in this direction, and Messrs. Cook and Hailstone have offered some excellent pioneering research.

In regard to malleable cast- iron, most of the commercial advances have been in the direction of copying American methods. There is a good field in this direction for commercial research, and a little application will open out wide fields to malleable castings made wholly from mixtures of ordinary British irons. So far as ordinary work in the brass foundry is concerned, perhaps the first field offered is in a study of the losses occurring during melting. The intrinsic value of the metals is such that standardisation of alloys and systematic chemical analysis will be found to pay. Special bronzes, non-corrosive, high-tension, etc., and white metals offer very good fields for exploration. The treatment of brass and bronze castings is also a question requiring attention, and it may be well to begin studying this matter. So far as general work is concerned, we require more accurate information as to the true economical possibilities of moulding machines. There is room for a very considerable advance in core making machines, with special reference to cores of irregular contour. Moulding sands are beginning to receive the attention they have long merited. Fuels, including electric heating, are receiving wider investigation, and the results will be of interest to founders. Many of the subjects briefly sketched are included in our programme for this session, and we therefore anticipate interesting papers and good discussions.

Finally, it will be well to touch on some aspects of published work. Much has been written with a view to aiding foundry progress. In reading, as in other things, discretion is often the better part of valour, however, we must of necessity follow all work reported. Any work bearing the impress of careful thought and experiment, no matter how much it differs from previous views, is worth earnest study. Good work is often criticised as not being practical, too scientific, etc. Criticism of this nature is intolerant, in that it simply represents the point of view taken, and not judgment of work done. Purely scientific work often has a very practical bearing. An abstruse subject such as the gases dissolved by metals would be very scientific, and if investigated on purely scientific lines would have very practical bearings. The word practical is one requiring considerable latitude in interpretation. The foundry chemist is just as practical as the moulder, assuming both to work to best advantage. Under some conditions the chemist can be just as much a rule-of-thumb man as the moulder is said to be.

In the Vacation Court, recently, Mr. Justice Neville had before him a motion to restrain the Inshaw Seamless Iron and Steel Tubes, Limited, from holding a meeting, called for October 4, to pass a resolution for voluntary winding-up, in breach of an undertaking given to the Court about two months ago. Counsel for the company said that in face of the undertaking he could not resist the injunction. He imagined that there must have been some misunderstanding. A scheme of reconstruction had been sanctioned by the Court, but since then a scheme which, in view of the creditors, was a more favourable one, had been put forward, and it was assumed that the petitioner would consent to the company going into liquidation to carry this new scheme through. His Lordship granted the injunction,

The Herman Jarring Moulding Machine.

The accompanying illustrations show the "Herman" patent pneumatic jarring moulding machine, which forms the mould about the pattern by jarring, instead of pressing or ramming in the ordinary way. Patterns moulded flat on power-ramming machines are made upright on the jarring machines, and the machine shown herewith will jar moulds with patterns from 1 to 20 in. high. Patterns and stripping plates used on other machines may be arranged for the jarring machine, and by the use of the turnover device furnished with the Herman machine a large variety of regular wood patterns may be used without stripping plates. The air pressure required to operate the machine is 60 to 80 lbs. per square inch, and pneumatic vibrators are utilised for rapping the pattern while the mould is being withdrawn. The principle employed is an up-and-down movement, striking upon a resilient surface.

be set on the top of the latter, and the sand thrown in even with the top of the hopper. The operating valve is then opened and the globe valve which is close to the machine closed; the air is turned on and the globe valve gradually opened until the machine jars in a regular manner. Once the globe valve is set, provided there are no heavy fluctuations in the air pressure, it requires no further manipulation, and all succeeding operations are carried on by the operating valve alone. With a little practice the exact hardness of the mould and the number of jars that is required to produce that can easily be determined. After the mould is jarred it is raised off the pattern, the lifting forks being placed in position under the stripping plate.

The jarring of the mould is precisely the same with the turnover machines as described above, except that no stripping plate is used. When the mould is jarred up and the sand struck off, a bottom board

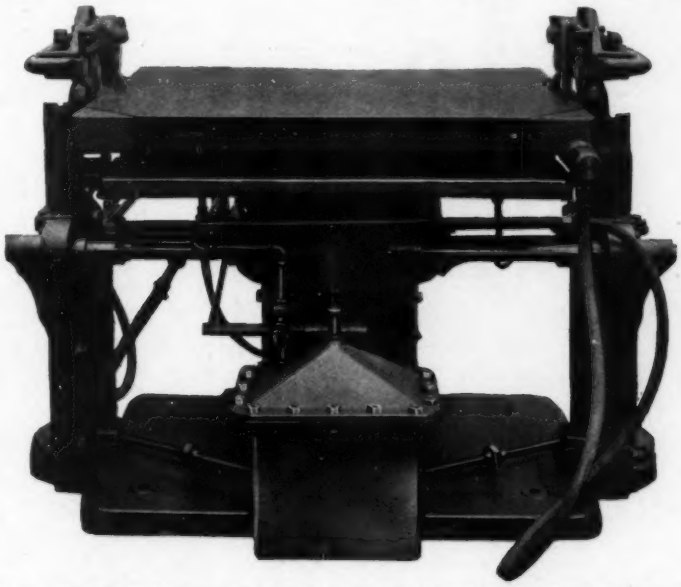


FIG. 1.—HERMAN JARRING MACHINE WITH OIL-GOVERNED LIFTING CYLINDERS.

With the variety of the "Herman" machine shown in Fig. 1 is adopted the principle of the oil-governed hoist—the cylinders for raising and lowering the pattern table and moulding box being governed by oil. By this means perfect steadiness of lift is secured. The smallest amount of vibration or unsteadiness in raising or lowering the load would almost certainly result in a break away. This oil-governed arrangement is found to be extremely successful, and at the same time is quite simple in operation.

The machine when in operation is set so that it will strike about 120 blows per minute. Fifteen to thirty jars are generally sufficient to set the sand in an ordinary sized mould. In operating the machine the stripping plate is placed over the pattern, and the moulding box put in position. A hopper (wooden or iron frame) from 2 to 5 in. deep, according to the height of the moulding box, should

is placed on top of the moulding box, and is clamped to the pattern plate, the whole being raised by means of the pneumatic cylinders, turned over and lowered on to the machine table. The clamps are removed and the lifting forks placed under the pattern plate and the pattern is drawn out of the sand. The moulding box is placed on the floor, and the pattern plate is returned to its original position ready for the next mould. These operations are the same as when moulds are rammed by hand on the floor, but they are all made with a mechanical precision requiring no hard labour. The turnover attachment can be removed from the machine very readily, and patterns with stripping plates can then be operated.

The parts of the jarring mechanism are confined within the cylindrical casing shown in the centre of the machine, and a flanged cover always encloses the upper part of the casing in all positions, so that the machine is rendered sand-tight.

When oiling the machine the plug in the supply pipe near the operating valve is removed and a quantity of thin machine oil poured in. The air forces the oil to the working parts of the machine. The pneumatic hoists on the side of the machine should be kept well oiled at all times. This is done while the piston rod of the hoist is raised, and when the oil becomes thick the rod should be thoroughly cleansed and new oil applied.

It may be mentioned that by means of the mechanism described above moulds may be rammed sufficiently hard for casting steel. The makers are

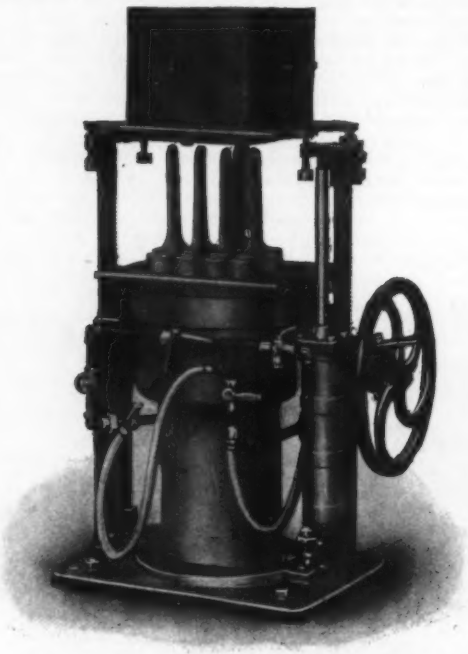


FIG. 2.—THE HERMAN PNEUMATIC JARRING MOULDING MACHINE.

the Pneumatic Engineering Appliances Company, Limited, Palace Chambers, 9, Bridge Street, Westminster, S.W.

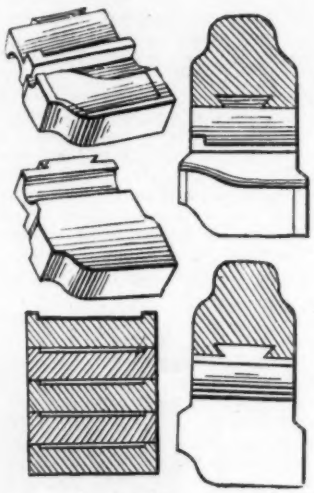
A Car Wheel Chill.

The contracting car wheel chill, for making various sizes of cast-iron car wheels, which is illustrated herewith, was the subject of a patent taken out by Mr. B. M. Carr, Superintendent Machinery Department Dickson Car Wheel Company, Houston, Texas.

For many years it has been known that the wheels made in contracting chills are far superior to those made in plain chills; in fact, many of the largest railroads specify their wheels made in contracting chills.

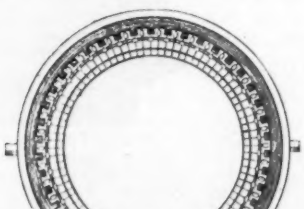
The invention consists of a series of segments. made rights and lefts, with dovetail ends placed together to form a circle with a small spacing strip on the face for the purpose of forming the slots, also for the purpose of relieving the gases from the mould. There is then a ring of metal cast around the dovetail end of the segments which binds them all together. There is no machine work necessary on the face of the segments, thereby retaining the outside surface or skin of the iron which protects it from the hot metal burning in. The slot is only about one-sixty-fourth to one-thirty-second of an inch.

The only machine work necessary to be done is to bore the same out to the proper diameter of the wheel. This enables the chill to be used the day



CARR'S CAR-WHEEL CHILL.

after being cast; in other words, does away with sawing and the expense of saws and special machinery for this purpose. It also does away with one day's coremaker's time, which is necessary on other contracting chills. The segments are made in the chill by the use of moulding machines, and are made rights and lefts, thereby doing away with all



CARR'S CAR-WHEEL CHILL.

core work. It is not necessary to do any drilling, as the two segments laid together each form half of the hole for the drag pins or receiving sockets.

The accompanying illustrations show the construction of the chill.

IT is officially announced that the President of the Board of Trade has appointed Mr. W. H. Beveridge as director, and Mr. C. F. Rey, as general manager, of Labour Exchanges under the Labour Exchanges Act, 1909.

A System for Pattern Storing.

By F. Tissington.

The object of this article is to describe a system which will improve and facilitate the methods of turning up old stock patterns, and this without any undue extra cost. It is no uncommon thing for the foreman and draughtsman to take a tour round the pattern stores looking for a pattern which somebody believes was made a year or so ago, and could be used again with very little alteration on a new job; but owing to no records being kept, and no real system of storing adopted, the hunt frequently resembles the search for the proverbial needle in the haystack. Again, if the drawing office staff is a large one, not one of its members can recollect every pattern that has been made, even if they should all pass through his hands, and more often than not the man responsible for a particular design will not be able to say when it was made, or be able to give one item of useful information respecting it. Add to these difficulties changes in the staff, and the result is probably that dozens of patterns are duplicated every month where there is not the slightest necessity for it.

The writer had some experience in this direction in connection with roof designing. No records of any kind were kept either in the office or works, and every time a gutter was required a new pattern was made to suit the particular roof, unless the search above referred to was adopted. Finally, however, all the existing patterns were got out (which, by the way, were all made in iron, and would thus stand any amount of repetition work) and full particulars as to sizes, thickness of metal, and weights of same, were taken. With the help of this list it has not been necessary to make more than about two or three new patterns during the last two years.

Essential Points.

The essential points of a system to deal with this problem are :—Simplicity; cheapness, or it won't pay you to run it; and reliability, or it will not be cheap at any price. The last is, of course, the most important, and upon it hangs the other two; because if the system is reliable it is generally simple, and if simple can be made cheap by putting lower-priced men to run it.

There are two departments to be considered—the office and the works. The objects to be attained in the drawing office are :—(*a*) Accurate drawings of each pattern made; (*b*) ready means of reference; (*c*) altering existing patterns to suit new castings; (*d*) accurate prime costing and estimating for new work, etc.

The Drawings.

(*a*) All drawings should be fully detailed and dimensioned in every way so that on turning the particulars up at any future time it is not necessary to measure up the pattern before it can be used again. This practice has an additional advantage, as the pattern-shop foreman does not have to waste his time coming to the drawing office for information about some doubtful point. If it is necessary to make any alterations after the drawing has been sent into the works, this should be clearly shown on the original, and a new copy issued to the foreman. Above all things the foreman should not alter anything without it first being put on his drawing.

It is a good plan to make all drawings on the same size sheets, as they are easier to store if this is done. For certain classes of work foolscap sheets with squared lines answer very well. If these are too small tracing cloth or paper should be used, so that any number of prints can be made as required. These can be filed laid flat in drawers, but should be kept quite distinct from working drawings not connected with the foundry, and also from drawings for inquiries, etc. Every drawing should have at least the following information on it :—Order number; name of article; number of castings to make; estimated and actual weights; and index number. All this information should be grouped at the bottom of the drawing so that it can be readily seen on opening the drawers without taking them out. In cases where the drawings will be used several times for repeat orders it is a good plan to have the order number, number of castings required, and actual weights, made in the form of a table, with half a dozen lines, the headings arranged at the top. The index number should always be put on boldly, and this is best done with a set of stencils, so that the size is kept uniform, and the best position is generally in the right-hand bottom corner. Drawings, which are numbered in sequence, should retain their proper places in the drawers.

Indexing for Reference.

(*b*) For this an alphabetical index is the best, and, if necessary, it can be enlarged by the addition of a second letter, thus :—Aa 10, Ab 11, Ac 12, and so on. This would be more useful where the patterns vary in size, say, from small collars to large columns, as it would be most difficult for the storekeeper to arrange these two articles in sequence, so that they may be easily found. If, however, the small collar were marked Ca 1, and the large column Cd 2, Cb 3 could then be used for a coupling-box pattern, and Cc 4 for a large crank disc, as intermediate size patterns. They would then be stored according to size. the column being reared up against the wall, the crank disc on the floor under the rack, and the other two patterns on the bottom and second shelves of the rack. If this system were used, the small index letter would only be of help to the storekeeper in locating the right position for storing the patterns, and not for sub-dividing the drawers used for storing drawings, although, of course, this might be done if the system required to be so large. These letters and numbers form the index number of the drawings under which they should be filed, the capital letter indicating the initial letter of the name of the article, the small letter regulating its position in the stores as to size, and the number the position of the drawing files and the patterns on the shelves.

To avoid confusion in filing, say, a bracket, which is a gutter or wall bracket, it should be filed and indexed under "B" and then cross-indexed under "G" or "W," quoting the number it is actually filed under.

The index book may be made up with loose leaves to admit extension, or may be of the ordinary bound type. It would be a help, also, in obtaining the exact drawing required, if a single line sketch were

made next to each number, giving just the outline of the article, and a line or two could be reserved for those patterns likely to be used regularly.

Altering Existing Patterns.

(*c*) There are always a number of existing patterns which can be used again with slight alterations, and this will always pay well unless the old pattern is of a standard article. It would, in such cases, however, be quite in order to add a piece to an existing standard pattern as this could easily be made so that a return to the original article would be a very simple matter. In the event of any alterations being made to an existing pattern, a fully detailed drawing should be made showing the new appearance of the article. This drawing should be filed under the same number as the original, copies should be issued to the foreman of the pattern-shop with a note indicating "Alterations to existing pattern,' and a note inserted on the original drawing, referring to the altered drawing.

If the article is only a small one and does not take up the whole space of the standard size drawing sheet, the alteration can be shown on the same sheet. It would be useful to insert the dates when the drawings were made, and this, with the number of castings which have been made off the pattern from time to time, which would also appear on the drawing, would enable the designing staff to form a very good opinion as to the probable condition of the pattern in question. If the same pattern is altered a second time, the same process should be repeated again. A note should appear on the drawing as to whether the pattern is likely to be standard or not, as this will often enable the foreman of the pattern shop to decide how to make a particular job.

Prime Costing and Estimating.

(*d*) The estimated weight of the casting should always be put on the drawing, as it makes the foreman careful in using cores of the right size, and in having his metal of the right thickness all over. The actual weights of the castings should also be entered on the original drawing against the order number, as the information is most useful in estimating for new work. It is far the better plan to have these weights obtained by somebody not interested in the result, for in cases where the dresser, who is paid by weight, gives this information, the result is likely to be more weight than is actually turned out of the foundry.

It is necessary for every pattern to have the index number of the drawing on it in a conspicuous position, preferably with raised letters and figures, so that they are included in the casting. This is handy if clients wish to give a repeat order for a particular casting, as they simply have to quote the number.

Storing.

Core boxes of a particular use for one pattern only should be marked with the number of the pattern they belong to, and these boxes should be stored with the patterns. Core boxes in constant use for a number of patterns will not require marking, and may be stored together on a series of racks. In the pattern stores all racks and wall spaces should be suitably divided off and arranged for easy extension of the system, with the divisions marked with the initial capital and small letters on good-size plates. As far as possible, it is always best to let one man have the job of storing, and he should be directly responsible to the pattern-shop foreman, who will issue requisitions for patterns required.

When patterns are sent out to the foundry by the pattern shop, it facilitates the work if a gummed ticket is put on the pattern giving the number required, and a note stating whether the pattern is to be returned to the pattern shop for alterations, or to the stores if the work is completed. Immediately the patterns are done with, they should be placed in a particular spot so that the storekeeper knows without asking that they are to be taken away.

The weighing, as before stated, should be done by someone outside the foundry and pattern-shop altogether. This man should have a ticket issued to him from the drawing office giving the number of castings, and the order number, and immediately the consignment is complete he should fill up a ticket in triplicate, giving the actual weights. These should be handed in to the cost clerk, wages clerk, and drawing office. This man could also do the consigning, requisition the foundry stores, and examine all castings for defects, etc.

Summary.

To summarise the foregoing:—On receipt of an order the head draughtsman gives the work out, and the designer turns up the estimate to see if any reference is made with regard to using stock patterns. If not, and it is probable an old pattern will work in, he obtains the index book and finds a likely number; issues this to the youth in charge of the drawers, and if it is suitable, makes the necessary alterations, if any, and hands the drawing over to the checker. This being satisfactory, copies are printed and sent to the foreman with the order number, etc., filled in. If a new pattern is required a new drawing is put in hand, checked, and entered in the index book by the man in charge of same, copies being printed and issued as above.

The foreman on receiving drawing with "Alteration to existing pattern" stamp on, gives instructions to the storekeeper, who obtains same, and alterations are carried out. After completion, the label is stuck on with instructions to the foundry, the castings are made, and the pattern disposed of. After dressing, the weigher takes particulars of actual weights and sends the information in as intimated above.

If any great discrepancy occurs in the calculated and actual weights, the cause is sought for and the party to blame called to account. If any patterns are broken up notice should be given to the drawing office at once, and a note put on the drawing.

It must, of course, be understood that the writer does not intend to suggest that the above scheme will suit all conditions, as each individual case must be treated on its own merits. At the same time it gives the idea of a system to suit some classes of foundry work, and suggests a feasible plan for other foundries to work upon to enable them to cut down the expenses in the offices and works.

JOSEPH SANKEY & SONS, LIMITED, are making considerable structural alterations to their Albert Street Works, Bilston. These, like so many of the older works in this district, have been extended from time to time, resulting in a multiplicity of more or less small shops, and the management are now doing away with these small shops by converting them into one building under one roof. Considerable additions are also being made to the electrical equipment at both the Albert Street and Bradley Works. Current is generated in the Works Central Station.

The Hauck Oil-Burning Appliances.

Oil-burning appliances such as those illustrated herewith are applicable to a number of purposes in a foundry. They may be used for skin-drying and baking moulds and cores, firing up cupolas, heating ladles, burning on castings brazing, melting of metals, etc. The "Hauck" portable burner which is shown in Fig. 1, is furnished with a hand-pump attached to the tank, and burns kerosene oil only.

FIG. 1.—SELF-CONTAINED HAUCK BURNER.

lated easily for either drying a large surface or for concentrating on a small area. For skin-drying moulds, etc., therefore, this burner is said to be very useful.

FIG. 2.—HAUCK BURNER FOR COMPRESSED AIR.

Various styles of "Hauck" burners are made to meet various foundry requirements. Fig. 2 shows the compressed air style of burner, which is usually preferred in foundries where compressed air is available. The burner can be used in connection with air pressure varying from 5 to 100 lbs., and any grade of crude fuel or kerosene oil can be used.

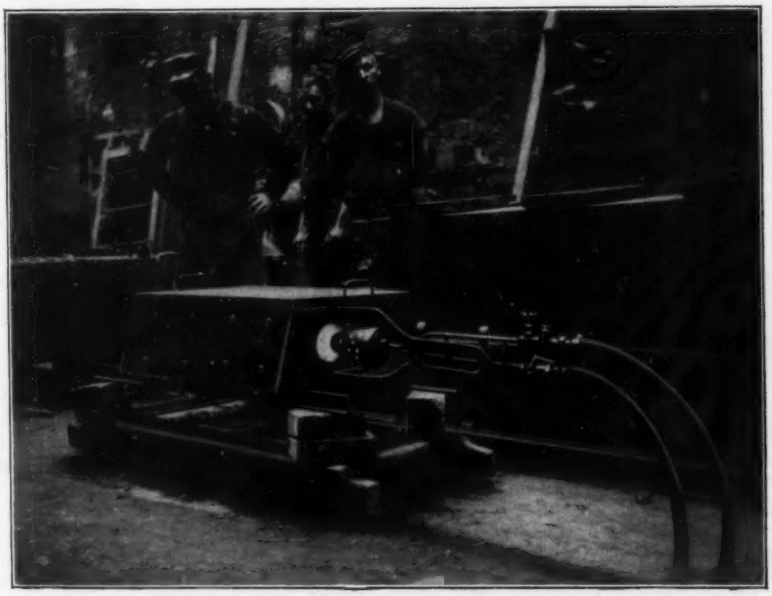


FIG. 3.—ARRANGEMENT FOR MOULD DRYING WITH A HAUCK BURNER.

After filling the tank an air pressure of about 12 lbs. is obtained by means of the hand-pump, and when this is shown on the indicator the burner is started. It is claimed that a soft, regular flame is obtained, which can be instantly started and regu-

The tank is filled with oil and the compressed air hose attached, when the burner is ready for use.

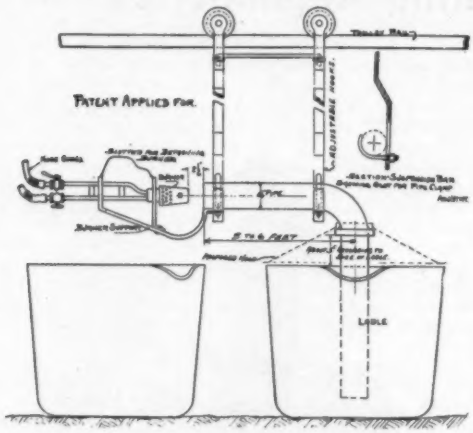


FIG. 4.—ARRANGEMENT FOR HEATING LADLES.

Fig. 3 depicts an arrangement for employing the "Hauck" burner for baking moulds, where it is not advisable to apply the flame of the burner direct. A sheet-iron box lined with asbestos sheeting is constructed, and the portable burner attached as shown. The flame being projected into this box causes a reflection of heat to the moulds, over which the device is placed. The cleanliness of this method of heating the moulds as compared with some other methods is greatly in its favour.

A convenient arrangement for heating large ladles, mixers, etc., is illustrated in Fig. 4. A pipe is arranged to conduct the heat through the top of a hood into the ladle, over the bottom and sides of which the heat is thus distributed, on the burner being fired and placed at the mouth of the pipe. One other successful application of the "Hauck" burner which may be mentioned is for lighting cupolas. It lights up, and creates the necessary air current in the furnace, while at the same time giving no smoke.

These burners are manufactured by the Hauck Manufacturing Company, New York, U.S.A., for whom Messrs. J. W. Jackman & Company, Limited, are the British representatives.

Microscopy in the Foundry.

MR. J. E. STEAD, in a lecture delivered recently at Copenhagen before the International Association for Testing Materials, said he would endeavour to give a few examples of cases in which macroscopy and microscopy had been found of great service to the steel maker and user. He had communicated with the greater number of metallurgical industries in Great Britain, and with the leading authorities in Europe and America, to ascertain the extent to which the microscope was actually in practical daily use. Mr. Stead then proceeded to quote from a number of replies that had been received, respecting the useful application of the microscope to iron, steel and brass foundry and other work. It was generally acknowledged that it served a number of useful purposes. Regarding auto-sulphur printing, the speaker said that the method first discovered by Professor Heyn and applied by him and by his assistant, Professor Bauer, and afterwards modified by Professor Baumann, if properly applied, was most useful in foundry practice. This method had been more usually applied for the detection of local and axial segregation of sulphur in steel, but it was capable of showing approximately the amount of sulphur in cast iron. It was only necessary to file and polish sections or rough chips of cast metal, and press the flat surfaces on to pieces of bromide paper previously soaked in a 3 per cent. solution of sulphuric acid in water, and allow them to remain in contact for one minute, after which they were removed from the paper, the acid washed out with water, and the prints fixed in hypo-sulphite of soda, then washed and dried. The brown stains remaining on the paper varied in intensity with the sulphur present in the iron. They were compared with standard stains prepared from metals with known contents of sulphur. Differences of 0.02 per cent. sulphur were quite easily detected in this way. Direct prints could also be obtained by contact on lantern bromide plates after saturating the films with the dilute sulphuric acid and removing the excess of acid with blotting paper, but in such case, pressure must be applied to the specimens after placing on the slides in order to get good impressions. On applying this process to complete sections of pig-irons, the fact was revealed that in highly sulphurous material the sulphur was very irregularly distributed.

As phosphorus in cast iron existed in isolated masses of phospho-iron eutectic, and as the amount of these masses bore a close relation to the percentage of phosphorus present in the pig-iron, an approximate estimate of the element actually presented might be made by examining polished and etched sections of grey pig-irons. The polish need not be more than that obtainable by use of fine emery paper. The etching was done with 20 per cent. nitric acid in water, and was continued until the surfaces of the metals appeared quite dark. On comparing the prepared specimens with similar sections of standard pigs, it was not difficult to detect differences of 0.2 per cent. in hematite pig-iron, and 0.5 per cent. in pig-iron containing between 0.5 per cent. and 2.0 per cent. phosphorus. It was not so easy to apply the method to small foundry castings, as the eutectic usually was not evenly distributed, and appeared in reticulated form. It was easy to tell whether white irons were high or low in phosphorus, but the polishing was not so easily effected.

The macro- and micro-structure of steel castings was of great importance to the steel founder. He could readily locate segregations and determine whether the sulphur was relatively high or low by the auto-sulphur printing process. He could check the work done in the annealing furnace and determine by the examination of pieces cut from the casting whether the annealing temperature had been too high or too low, and whether or not the castings had been annealed.

In foundry practice, where the facings of the moulds consist of a graphitic mixture, the outer envelope of the steel in contact with the mould itself was usually higher in carbon than the mass of the metal. When the annealing had been properly done, the envelope was completely decarburised, and the castings sheathed in a thin covering of carbonless iron or ferrite. This decarburised layer varied in thickness with the time and temperature, and with the percentage of carbon in the steel. In steels containing about 0.30 per cent. to 0.35 per cent. carbon, it was sometimes only 0.05 mm. in thickness when the castings were small, and as much as 1 mm. in large castings. In unannealed steels the ferrite envelope was almost invariably absent. The altered micro-structure of the mass of steel produced by annealing, as compared with the "casting structure," was usually sufficient to enable one to say whether the steel had been annealed, but not if the temperature of annealing had been excessive, and it was in such cases that the decarburised envelope had to be looked for. A thick ferrite envelope and a coarse triangular structure of the pearlite in the steel itself were indicative of annealing at excessive temperatures. The presence of granular pearlite indicated clear evidence of prolonged annealing at temperatures between 750 degrees C. and 650 degrees C., and steel in this condition was usually very soft. When the annealing was done by heating to between 850 degrees and 900 degrees C., and the steel was removed from the furnace and cooled in the air, the pearlite was nearly always of the lamellar variety.

It was now a common practice to improve the surfaces of defective steel castings by electrically melting and filling blow holes with iron or steel. It was recognised in important work that the castings should be annealed after electric welding. Etching with 20 per cent. nitric acid, after rough polishing, would show at once whether electrically welded steel had been annealed or not, for, if not, the steel surrounding the weld always consisted of either martensite, troostite, or sorbite, and each of these gave a dark stain on application of the strong reagent, whilst the iron melted electrically and used to fill the cavities was always in the form of ferrite, and remained white after etching. This etching method was, therefore, most valuable, for it enabled the works' inspector or engineer to determine on the finished work the areas welded, and whether or not the steel had been annealed after welding. Annealing not only changed the troostite, etc., into pearlite, but removed the strains set up by the excessive local heating.

In the manufacture of malleable castings, the microscope was useful in determining to what extent decarburisation had taken place, and whether there was anything abnormal in the structure of the metal. The outer skin of both black heart and white malleable castings was, after normal annealing, free from carbon. If the castings were very small and of very light sectional thickness they were frequently more or less completely decarburised and exceedingly soft and ductile. The microscope enabled one to detect with absolute certainty the extent of the decarburisation. Occasionally one came across white heart malleable castings covered with a brittle metallic skin, which peeled off on attempting to bend the metal. The skin contained the silicon of the metal oxidised to silica. In other cases the outer envelopes contained carbon, and this covered a layer of decarburised metal. For reasons not quite evident, it was certain that during the annealing, re-carburisation to a slight extent occurred, but whatever the cause might be, the microscope enabled one to readily detect the abnormal condition.

There was no better method of controlling the workmen who were responsible for the proper case-hardening of iron and steel than by the use of the microscope. Sections of hardened case-hardened material, after polishing and etching, indicate with certainty the depth to which the carbon had penetrated the metal.

In the works, as in the laboratory, it was essential that the examination of metals should be made from every point of view.

Having obtained auto-sulphur prints, sections might be immersed for about half a minute in 20 per cent. nitric acid, or for one minute in Heyn's cupric chloride reagent, the former when a rapid etching was required, and the latter when the operator wished to keep the specimen. Both reagents gave a dark colouration to the surface in the areas of highest phosphorus. Without exception, those stains corresponded exactly with the maximum sulphur stains given by the auto-sulphur prints.

COST OF MAKING COPPER.—According to the Boston (U.S.A.) "News Bureau," the average cost of making copper is a fraction over 5d. per lb. If construction and improvement work are treated as operating charges, the average is raised to 5¼d. The copper mines of America are producing at the rate of somewhat over 1,360,000,000 lbs. of the red metal per annum. The current expense of recovering this product is £27,611,000, an enormous sum, and of which probably 65 per cent. represents the cost of labour. This huge copper total with respective costs may be subdivided as follows:—

Output—lbs.	Average cost per lb. Pence.	Total costs.	Per cent. of total.
483,000,000	4½	£8,210,000	35 6
168,000,000	5	3,360 000	12.4
525,000 000	5½	11,287,400	38.6
191,000,000	6½	4,754,000	13.4
	5	£27,611,400	100.0

From a closer view of the above table it will be seen that but 35.6 per cent. of America's output may be classified as low-cost copper. In this group are included all companies making copper for 4½d. per lb., and under. Lake Superior, with the premier Calumet and Hecla, contributes 141,000,000 lbs. of the 483,000,000-lbs. total, or about 30 per cent. The Copper Queen of Arizona furnishes 100,000,000 lbs. of 4½d. copper, and the Utah Copper Company furnishes 60,000,000 lbs. The next group, comprising 168,000,000 lbs. of output, or 12.4 per cent. of the total, includes copper made at over 4½d. per lb., and not more than 5d. per lb., the most conspicuous member of this class being Boston and Montana with 90,000,000 lbs. of 4¾d. copper. The largest division, embracing 525,000,000 lbs., or 38.6 per cent. of the total, covers copper made for 5d. and not over 5½d., and in this category are such properties as Anaconda, Butte Coalition, Osceola, Quincy, Mohawk, Boston Consolidated, Greene Cananea, Granby, Old Dominion, Detroit, Arizona Copper, and others. The last division is made up of miscellaneous production in all sections of the country. It embraces copper made at a cost of over 5½d., and there is here included a vast amount of metal which is produced at an absolute loss. This product constitutes almost 15 per cent. of the total, and in some respects is the real menace to the copper market.

The Casting of Brass.

By A. Napier.

(*Continued from page* 615.)

Furnaces.

As already indicated, the crucible furnace is the most suitable for melting brass, apart from various special and patented furnaces that have been introduced during recent years. These, in most cases, are elaborated crucible furnaces, and are certainly often very convenient furnaces to work. It is not necessary to enter here into the question of brass furnace building and working, for the essential principles are fairly well understood by most foundrymen. It is necessary, naturally, to give careful consideration to the size of pot which will be the one most generally used in the particular foundry or furnace, in order that economy in fuel may be attained. It is also necessary to see that the combustion of the fuel is as perfect as possible compatible with good melting. While coke firing is the most popular for general work, oil has lately come to the front for brass melting, particularly in America, but the effects of an oxidising flame, and a reducing flame respectively, must be understood otherwise trouble is very likely to occur. An oxidising flame—resulting from an excess of air, and consequently oxygen—means that the metal will be oxidised during the process of melting, the effect being similar to that of blowing a stream of air on to molten metal. A reducing flame contains in excess carbon, or hydro-carbons, and consequently does not give perfect combustion of the fuel. This involves a loss of heat and probably considerable smoke, though from the point of view of good metal it is to be preferred to an oxidising flame. The happy medium should be hit—this is the point where only just sufficient air is introduced to secure good combustion of the fuel. Thus, the regulation of the fuel and air supply is an important matter with oil-fuel furnaces. With coke and gas furnaces, too, the air supply must be adjusted to give the best combustion of the fuel without introducing an excess of air. A thorough understanding of the metals being used, it is scarcely necessary to say, is essential for good working, or serious losses may result. Incidentally, it may be mentioned that one fault which some melters are guilty of lies in the careless packing of the crucible. It is necessary not only to arrange the metal so as to get the least possible waste, but it must be packed, in the first place, in such a way that the crucible will not be unduly strained when it is hot. Particularly when large pieces, or ingots only, are being melted and the pots will not properly accommodate the long pieces, there is sometimes a tendency on the part of the melter to pack them too tightly, in order that on melting they shall not fall over the sides. This, of course, endangers the crucible, which is likely to break even before the metal is melted. If economy in pots is to be considered—and it is a very important matter—the point is worth a deal of attention.

The care necessary in melting brass to prevent oxidisation of the different constituents of the alloy cannot be insisted on too frequently, as from this cause many castings are spoiled. As has been explained, charcoal is used in melting brass to prevent oxidisation of the metal. Copper, particularly, oxidises rapidly when in a molten condition, and at the same time it is liable to the absorption of gas and sulphur. The charcoal forms a protecting covering, and allows the melting to proceed properly without the metal coming into contact with the atmosphere or other gases which are present in the furnace. The charcoal should preferably be crushed small, and be slightly damp, and a small quantity should be placed in the bottom of the crucible before the metal is put in. More should be added as the metal begins to melt. Small coal or coke is frequently used in place of charcoal, but on account of the presence of sulphur in these materials they are inferior. Charcoal, on the contrary, is entirely free from sulphur and hydrocarbons, and at the same time burns readily, thus supplying a reducing atmosphere.

Moulding.

Brass moulding is similar in many respects to iron moulding, and the author does not propose to enter into a detailed description of the work. A few points, however, may be touched upon. There are a few features about moulding for brass work that differ from iron practice, and these differences must be borne in mind. The general impression is that brass founding is a simple matter, and that if iron moulding rules are followed, success will result. There are a good number of founders who do a small quantity of brass work in connection with engineering work that comes into their hands, and to such men a few hints will perhaps be valuable. The sand used for brass work should be of a finer grade than that used for iron moulding. This applies more particularly to fine work; for heavy work that has to be machined, it is no disadvantage to use a coarser and more open sand than for fine work. Venting must be freely done, on account of the closeness of the sand, and in some cases for heavy work it is advisable to use dry sand. One great difference between brass and iron moulding is that for the former larger gates must be used and the venting must be given more consideration. The runners also should not be very long, as long runners cool the metal. For manganese-bronze particularly, great attention is required in regard to gating. The old rule of gating on the heavy part of the casting does not apply, for it is much better to gate on the light part and put a riser on the heavy part. The gate for this work, while it should not be too long and unduly chill the metal, should be sufficiently long to collect dross which may enter, for it is found from practice that a long gate has this effect. The risers also require considerable attention if soundness is to be a feature of manganese-bronze work, though not infrequently brassfounders wilfully neglect this matter, and often pour the casting without risers. The riser should be sufficiently large to keep fluid until the casting it is feeding is set: otherwise it is of little use, and may, in fact, tend rather to draw from it than feed it. There are, of course, a number of castings made in every foundry that are too small to require the use of risers, but when the work is heavy the shrinkage must be dealt with in this way, for the shrinkage in brass and bronze is greater than in cast iron.

The mould is not prepared in the same way as for iron. For very light work no facing is required if a fine moulding sand is used, but for fairly light or medium castings facings of flour, pulverised soapstone or charcoal may be used, while plaster of Paris, and also bone dust are sometimes employed. For very heavy work plumbago may be used as a facing for the mould.

A convenient form of flask for small and light work is one provided with openings at one end which can be used for pouring-holes, the finished mould in the flask being set on end with the openings up. But the snap flask, *i.e.*, the flask which is hinged at one corner, and has a latch at the diagonal corner—is also a useful form for light work. By its use a number of moulds can be made from the one flask. As pouring a flask on end is often desirable, it is interesting to note this has been done in at least one American foundry while employing snap flasks. A simple arrangement of two iron bands placed inside the cope and drag halves of the flask before ramming up served to hold the mould together on the flask being removed, and by means of top and bottom boards clipped together on the moulds, these latter could be stood on end for pouring.

For manganese-bronze work the best results are obtained with dry sand, though green sand is more frequently used. In either case the venting should be carefully and thoroughly done. The mould for this work does not require to be blacked or washed, as the metal leaves it quite cleanly. Metal moulds for brass casting have been employed for some time, and with varying success, though as the science of alloys is becoming better understood, so is the use of metal moulds becoming more successful and popular. Since these moulds are permanent and practically indestructible with ordinary usage, they have many advantages over sand moulds for repetition work, this being, of course, the only suitable class of work for metal moulds, which would be too expensive to produce for only a few castings. Suitable sand cores are used, as in the case of ordinary sand moulding, and the mould before being closed is either smoked, dressed with oil, or treated in some other suitable way to prevent the casting adhering to it. Metal moulds have the advantage of giving a clean and dense casting and consequently are very suitable for a variety of work.

Melting, Pouring, etc.

Not the least important part of brass foundry work is the pouring of the metal. Not only must the mixture be melted in a suitable manner, but the temperature of the metal on pouring must be regulated according to the mixture and the casting. It is impossible to give more than a few broad hints on the question of pouring temperatures, for practice and experience count for more than written instruction. In the case of manganese-bronze, the course of the metal should be uninterrupted, and the metal in pouring should have as short a drop as possible, to prevent disturbing it, as it forms dross on being disturbed. The pouring, on the other hand, should not be too rapid, in order to allow the dross to be collected at the gate.

A class of work which requires special care and attention is the production of valve castings, which have to stand a pressure test, and frequently are liable to leakage under the test. For such work as this aluminium is an undesirable constituent, while too much zinc also is liable to cause dross in the metal and give leaky places in the castings. Absorption of sulphur or gases in the furnace as a result of bad melting conditions may be another cause of trouble. Unless the runner is long enough to collect any dross—and some is almost inevitable—and prevent it passing into the mould, this will again cause leakage, as will, also, the use of inferior scrap, which too often does not melt cleanly. But perhaps the most frequent cause of defective valve castings is pouring the metal too cold. The heat at which the metal is poured must be sufficient to burn the film of zinc oxide which always forms on the surface when exposed to the air. In case of other castings too, the metal should be poured with a view to reducing every chance of oxides forming on the surface of the metal (this often being accomplished by a sufficiently high temperature), and allowing any dross to collect at the gate without being carried into the mould. As regards the cooling of the castings, it may be stated here that slow cooling tends to harden brass, while sudden cooling softens it. As a soft casting is often required, this sudden cooling may be obtained by immersion in water.

As manganese-bronze is being increasingly used for a number of purposes, a few remarks on this alloy may be of interest, as it is somewhat difficult for the founder to deal with. The art of casting this alloy requires special study, or failure is likely to be a continual occurrence. For melting, the crucible furnace is the best, as those furnaces which allow the flame to come into direct contact with the metal cause a considerable loss of zinc. Unfortunately, the large furnaces, such as the reverberatory furnace, are practically essential if large quantities of the metal are required at one time. Their use can, however, be avoided by using a number of crucibles and pouring the metal into a ladle, and this method is adopted where first-class work is required. In melting the ingots, they should not be allowed to protrude from the top of the crucible so that they come into direct contact with the flame, or oxidation and absorption of gases will be too great. A much better result is obtained if the metal is filled so as to allow a covering of charcoal. The use of any flux other than charcoal is not desirable with manganese-bronze, and the heating should not be fierce, though not too slow. The surface of the metal as it melts should be kept covered with charcoal, and if it becomes so hot that the zinc fumes are given off freely, it should be cooled with good scrap, such as gates, etc. The metal should not be allowed to remain long in the fire after it is properly melted, or loss of zinc and probably gas absorption will occur. Thin castings of manganese-bronze should be poured at a rather higher temperature than thick ones, and though it is difficult to lay down any rule to govern this, the temperature of the metal for thick work may be said to be that at which the surface of the metal scarcely smokes at all unless disturbed. On the surface of the metal being disturbed slightly the oxide of zinc fumes should be gently given off. When the undisturbed surface is giving off slight fumes of zinc it may be taken as right for thin castings.

The author does not propose to enter the subject of mixtures for particular purposes, the foregoing notes being intended rather as hints for general practice.

Mr. T. Pedley, of the Love Lane Foundry, Walsall Street, and the Midland Foundry, Lichfield Street, Willenhall, brass and ironfounder, paid a first dividend of 3s. in the £ on October 20 last.

Mr. J. W. Beswick, of Temple Chambers, 33, Brazennose Street, Manchester, has been appointed as the representative in Manchester and district, of the Accessories Manufacturing Company, Limited.

Institute of Metals.

Autumn Meeting at Manchester.

The Autumn Meeting of the Institute of Metals was held on Thursday and Friday, October 14 and 15, at Manchester. The general gathering of the members took place in the Hall of the Municipal School of Technology, Sackville Street, when a selection of papers was read and discussed. Abstracts of some of the papers are presented herewith.

THE COPPER ZINC ALLOYS: A STUDY OF VOLUME CHANGES.

By Professor T. Turner and M. Thornton Murray.

In the introduction to this subject Professor Turner states that for some years past investigations have been in progress in the University of Birmingham on the changes in volume which occur when metals pass from the fluid state to the temperature of the air. Important results have been obtained in the case of cast iron which has been proved to have three definite expansions while the solid metal is cooling, these arrests corresponding to particular temperatures, and the separation of certain ingredients. The experiments have now been continued in a study of the alloys of copper and zinc which, as the brasses, constitute the most important of the industrial alloys. Mr. M. T. Murray was entrusted with the research, and his paper on the subject was presented to the meeting in very nearly its original form. The hitherto unrecorded fact is published that with certain percentage of zinc and copper the metal when poured into the mould does not immediately begin to contract, owing to the cooling as might be anticipated, but for a short time actually expands. This expansion, no doubt, accounts for the excellent impression of the mould and the sharp lines which are met with in certain brass castings. Ore alloy with about 15 per cent. of copper expands in a most remarkable manner, so much so, indeed, that after the metal has finally cooled and shrunk in the mould the bar is as long as the pattern from which it was cast. It is curious to note, however, that some of the alloys in the series do not expand at all when solidifying, these being the brass with 60 per cent. of copper, known as Muntz metal, and that with 40 per cent. of copper which is a hard, white brittle alloy, and probably a definite chemical compound. The authors have also determined the hardness of these alloys and find that the 40 per cent. alloy is the hardest of the series, and that it is actually much harder than mild steel. The experiments are likely to have an important theoretical as well as practical bearing, as it is believed expansometer tests will be more largely used in future as an aid to the determination of the constitution of alloys.

In a "Note on Shrinkage," by Professor Turner, which forms an appendix to the paper, he remarks that shrinkage may be defined as the difference between the length of a casting and that of the pattern from which it has been produced, and therefore, does not take into account the various stages of contraction, arrests, or actual expansions which may occur, but deals merely with the final result, or algebraic sum, of the volume change. Iron-founders frequently experience loss and inconvenience from warped or broken castings due to irregular or excessive shrinkage. One common trouble is the cracking of a casting either during or after cooling. Three chief causes contribute to this effect—namely, that hard metal usually shrinks more than soft; that thin castings shrink more than thick ones; and that in most soft irons marked expansions occur at certain definite temperatures. The brass-founder is not free from similar troubles, though he does not suffer to the same extent.

"Actual experiments," says Prof. Turner, "showed that thin copper or brass castings do not contract more than thick ones, and, indeed, in some instances, the opposite is the case. Mr. Simpson's tests, confirmed by Mr. Murray, show that in the copper-zinc alloys with from 100 per cent. copper to about 70 per cent. thick and thin bars behave practically alike. In other words, there is no chilling effect due to rapid cooling. The same is true with about 60 per cent. of copper, and also with from 40 to 10 per cent. On the other hand, alloys in the neighbourhood of 65 per cent. of copper, and also those with about 50 per cent. of copper, shrink *less* in thin bars than in thick ones; or, in other words, behave in a manner which is exactly opposite to that of cast iron."

THE TECHNICAL ASSAY OF ZINC.

By H. W. Greenwood and Dr. E. J. Brisler.

The paper presented by the joint authors represents work undertaken with a view to determining the relative value and accuracy of the various analytical methods for the determination of zinc, and also the gathering together of the more important references to the analytical chemistry of zinc in both British and foreign literature. The authors review briefly the more important processes, volumetric, gravimetric, and electrolytic, for zinc estimation. As a volumetric method they prefer Schaffner's, on the grounds of its accuracy, definite nature of endpoint of reaction, and general applicability. A number of results are shown in support of their contention.

The gravimetric estimation of zinc is not recommended by them as a technical method, but when necessary they prefer the estimation as pyrophosphate for moderate quantities and a modified calcium-zincate method for small quantities. Electrolytic methods are not, in the opinion of the authors, to be recommended for technical work. Good results can be obtained by several methods, but the deposit is difficult to deal with, and for that reason volumetric methods have been found much more advantageous.

A number of methods for the assay of zinc ores and alloys are dealt with, some of which the authors believe have not hitherto been published, notably a method for the estimation of zinc and aluminium in alloys of those metals, by the weight of hydrogen evolved on solution of the alloy in hydrochloric acid. This method is given as follows:—

About 0.5 to 0.6 gramme of the alloy in the form of turnings is weighed out and dissolved in hydrochloric acid. The hydrogen which is evolved is allowed to displace water from a large bottle fitted with two tubes, one reaching to the bottom of the bottle, the other ending just below the rubber stopper. The water is collected in a measuring cylinder and the whole apparatus allowed to gain constant temperature. The water is then measured to the nearest cubic centimetre and the temperature and pressure observed. After correcting the volume for temperature and pressure the weight of the hydrogen is cal-

culated, and from this the proportion of zinc and aluminium in the alloy.

Let g be the weight of alloy taken, and let x be the weight of the aluminium present, then $(g-x)$ is the weight of the zinc present, and let w be the weight of hydrogen evolved from g grammes of the alloy.

Now, since 1 part by weight of hydrogen is displaced by 9 parts by weight of aluminium, or by 32.7 parts by weight of zinc, we have

$$\frac{x}{9}+\frac{g-x}{32.7}=w,$$

solving for x

$$x=\frac{294.3w-9g}{23.7},$$

and hence the percentage of both zinc and aluminium in the alloy can be obtained.

The agreement is good when the proportions of aluminium and zinc are nearly equal.

Weight of alloy taken.	Weight of hydrogen.	Percentage of zinc and aluminium.
Gramme.	Gramme.	
0.6200	0.04804	41.1 per cent. zinc. 58.9 per cent. aluminium.
1.0030	0.07793	41.3 per cent. zinc. 58.7 per cent. aluminium.
1.0120	0.07877	41.34 per cent. zinc. 58.66 per cent. aluminium.

This alloy was made up to contain 58 per cent. aluminium and 42 per cent. zinc, and in the making up of the alloy a small quantity of zinc is lost, which accounts for the apparently low figures obtained. When the proportion of zinc is small in comparison with the aluminium the agreement is not quite so satisfactory.

If the alloys contain small quantities of copper and iron, as they frequently do, the copper is left behind as a sponge, which can be filtered off and estimated by any of the methods in use, the iron can be determined in the solution, and the volume of hydrogen corrected for the hydrogen due to the solution of the iron before the calculation of the percentage of zinc and aluminium is made.

THE ELASTIC BREAKDOWN OF NON-FERROUS METALS.

By Professor C. A. M. Smith, B.Sc.

This subject was treated to considerable length in Professor Smith's paper, and an abstract only was given at the meeting. The author said that some three years ago he commenced to attack the problem of the cause of elastic breakdown of materials used in engineering work. Various researches and investigations published by him showed that the solution of the problem as regards mild steel was different to that generally accepted by engineers in this country and on the Continent. Elastic failure of mild steel always took place, under any system of loading, by reason of the shear stress. Having proved that, he wished to find out whether all other ductile materials followed the same law. He could only say that they appeared to do so; he could produce no exact experimental evidence. The reason was that copper, aluminium, Muntz metal, and various other materials appeared to be much less homogeneous than mild steel. In a word, the result of his researches proved that, so far as the elastic properties of the material were concerned, mild steel was much more reliable than other materials. He produced the results of a large number of tests upon various materials and described in detail the instrument which he has invented for measuring small strains, and which is known as the sphingometer. It is an exceedingly simple device, and measures extensions of length of the astonishingly small amount of a quarter of a millionth part of an inch. It has been especially useful in testing work and will measure torque strains as well as extensions of length. Among the interesting facts which Professor Smith's experiments reveal are the peculiar fracture of aluminium and the effect of low temperature heat treatment on the non-ferrous metals. The work has been conducted at the East London College (University of London), and Professor Smith mentioned that but for the kind interest of the President of the Institute (Sir William H. White, F.R.S.), it would not have been possible to obtain the material and the equipment required for such accurate work.

SOME CAUSES OF THE CORROSION OF COPPER AND BRASS.

By E. L. Rhead.

This paper may be summarised as follows:—

Copper and copper-zinc alloys in contact with saline solutions, such as sea-water, corrode in a peculiar manner. Brass condenser tubes exhibit deep pits on the side next the water. These often occur in lines. In other situations and under other conditions copper enrichment takes place. The pits in the case of condenser tubes are commonest on the side of the tube lying undermost when the tube is in position. This corrosion is most erratic. It is generally attributed to selective chemical action, and to electrolytic effects due to the duplex structure of the alloy.

In the experiments mentioned in the paper samples of hard copper and brass were submitted to corrosion in various saline solutions, and their behaviour noted. Some of the solutions were saturated with carbonic acid gas. The figures obtained showed the greater tendency of the hard material to corrode. The edges and parts of brass plates that were scratched showed deposition of copper.

Strips of hard brass were softened at one end bent into U shape. When the free ends were put into corroding solutions, the hard limb dissolved more extensively and rapidly than the soft limb, the hard metal appearing to form an electric couple with the soft metal. Corrosion occurred in lines parallel with the direction of rolling. The surface of the hard metal was made very rough and irregular. That of the soft metal remained smooth. These roughnesses may form points from which the disengagement of gases dissolved in water flowing through condenser tubes may take place, thus facilitating the pitting and hastening the corrosion and failure of the tube. From this it would appear that the final cold drawing of a tube to produce stiffness is liable to produce irregularities that may increase the rapidity of attack.

THE CONSTITUTION AND PROPERTIES OF THE ALUMINIUM-COPPER-TIN ALLOYS.

By J. H. Andrew, M.Sc., and C. A. Edwards.

Many of the industrial non-ferrous alloys contain more than two metals. These mixtures have been arrived at by the method of trial and failure, and, as a consequence, possess in a more or less degree the required properties for their particular purpose. This method of working was the only one available up to a comparatively recent date. But now, with

the aid of the microscope and pyrometer, the constitution of alloys can be determined, and from such data the properties and correct heat-treatment deduced. Very little is known of the constitution of alloys containing more than two elements; therefore, it cannot be said that the ternary alloys in use are the best possible mixtures of their components. In making the choice of aluminium, copper and tin for the researches, which the writers present in this paper, they were influenced by the following facts:—(1) The constitutions of the three series, aluminium-copper, aluminium-tin, and copper-tin, have been investigated. (2) There is a desire to substitute aluminium for tin in brasses and other industrial alloys. (3) It appeared of some interest to ascertain the effect of a third metal on the transformations of such complicated alloys as the aluminium-copper and copper-tin series.

The conclusions arrived at by the authors may be summarised as follows:—(1) No ternary compound is deposited from the liquid alloys. (2) No ternary eutectic is formed. (3) Judging from the constitution and appearance of the alloys, it is clear that those possessing reasonable mechanical properties are confined to two very limited areas, viz., those containing upwards of 86 per cent. of copper, and those which contain more than 85 per cent. of aluminium. (4) Viewed from a theoretical standpoint no advantage is to be gained by adding tin to those alloys containing about 10 per cent. of aluminium and 90 per cent. of copper. (5) The authors think it probable that an alloy containing about 6.5 per cent. aluminium, 5.5 per cent. of tin, and 88 per cent. of copper, will have the same properties as an alloy containing 10 per cent. of tin and 90 per cent. of copper. Such a ternary alloy would be cheaper than the copper-tin, and would have a lower specific gravity. (6) Alloys containing the compound $CuAl_2$ with tin may be found of use as bearing metals, for when made under certain conditions they consist of a very hard constituent embedded in a soft matrix of tin.

Green-sand Cores.

By G. Buchanan.

Green-sand cores are not used at all in many foundries; but their advantages in certain classes of work are well-known, and it is the writer's opinion (based on actual practice) that a lot remains to be done along these lines. Green-sand cores, as a rule, require some slight modification on the part of the moulder when preparing his mould, but these differences generally entail no extra work, and consist in a preparation of the core prints of the casting, as broken corners are more easily mended and smoothed over, and the piece presents a more uniform appearance in regard to smoothness of surface, being alike both outside and inside.

Three examples of the application of green cores to a type of general engineers' castings are given herewith. The first, Fig. 1, is a D cover; this piece weighs about 300 lbs., and is made from a solid wood pattern having a

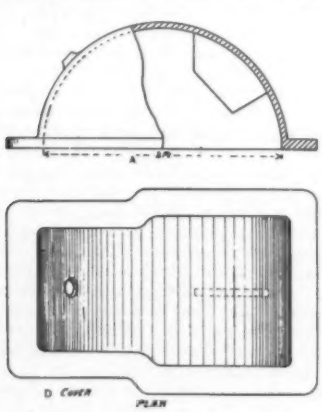


FIG. 1.

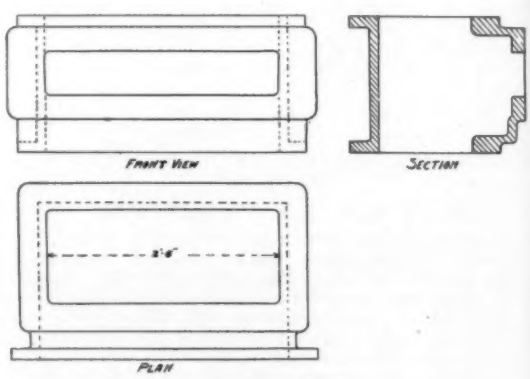


FIG. 3.

mould different to when dry sand cores are used. One advantage of a green core, when it can be used, is that the mould and core can be made, closed and cast in quicker time from the time of receiving the order than would be the case if the core had to be dried (perhaps for a night) in the stove. Another advantage is that the green core is made close by the mould and is only handled once, when it is lifted into the mould. The green core is also more easily removed from the casting; and in many cases a better and cleaner interior is obtained in the core print at its base A, and a core box with an open bottom. The core is rammed up on a flat board, a core plate of the same shape as the print being first placed in the bottom of the core box. A staple is cast in the centre of the core plate so that the core can, when rammed up, be easily lifted into the mould. Fig. 2 shows sectional and plan views of the mould, showing the green core set. It will be seen that a pocket of cinders is placed in the core and the vent led through a hole in the core plate, out through the

bottom of the mould at B. When only one or two pieces are required a board is used to lift the core by, a good, strong wood screw being used instead of the cast-iron plate and staple. When, however, as in the present case, twelve or more castings are wanted, the plate is more economical, as the board soon gets burnt.

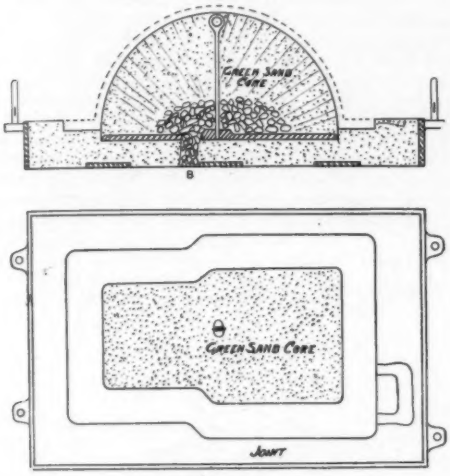


FIG. 2.

Fig. 3 shows views of a chest pattern. This piece weighs about 600 lbs., and is made from a solid pattern and core box. Fig. 4 is a sectional view of the mould with the green core set. This piece is somewhat similar to the first example, but there are several differences. A similar lifting plate and staple is used, and it will be noticed that overhanging portions of sand are well supported by irons

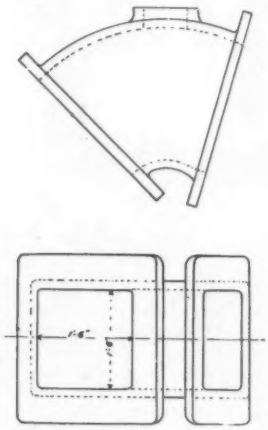


FIG. 5.

D, D. As the core cuts through at the top, the vent is let out at V.

Fig. 5 is a plan and front view of a distance pipe. This piece weighs about 650 lbs. Fig. 6 is a plan and section of the mould and core. In this instance a special core iron is necessary. This is made similar to a moulding box top part in regard to bars, and a staple is cast in the centre to lift the core into the mould. The pattern used is a split-wood solid pattern and core box with open bottom. The core is formed on a suitable flat plate by first placing the core iron in the bottom of the box before placing any sand. The two bars H, H, it will be seen, are about ⅜ in. lower than the body of the core iron, so that when the core is rammed up these two bars are level with the bottom of the core surface, and when the core is placed in the mould these bars rest on suitable supports which have been placed in the core prints at E, E. This supporting of the cores is a point which requires great

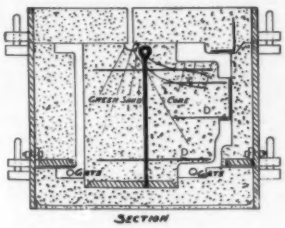


FIG. 4.

care in green-sand cores, but when placed, as the moulder terms it, "iron to iron," as shown on the sketches, no danger from crush need be feared.

These few examples are taken from work at present in progress, and belong to one class of casting as regards weight, being classed as rather heavy chunky pieces. No special patterns or core boxes are used. The patterns were supplied by a firm of engineers, and dried cores had previously been used

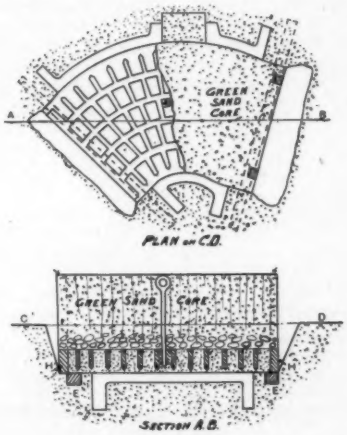


FIG. 6.

for these pieces; but on account of pressure of work and a limited core-oven capacity, the writer adopted the use of green-sand cores and found them quite satisfactory.

THE new John Morley Chemical Laboratories, which have lately been added to the buildings of Manchester University, were opened recently by Sir H. Roscoe. After several addresses had been delivered, Sir H. Roscoe, who was at one time Professor of Chemistry in the University, gave some interesting reminiscences of its early days, and paid a tribute to Mr. Carnegie, by whose beneficence the new laboratories have been provided.

The Electric Smelting Process for Iron and Steel.

In our issue of May last we published some particulars and illustrations of an electric furnace for the smelting of iron ore, which was being erected by the Aktiebolag Electrometal Ludvika, Sweden. This furnace was of the design employed at the Domnarfvet Works in the experimental work which has been carried out there, which has resulted, it is claimed, in the commercial solution of the problem of smelting iron ore in the electric furnace.

In a paper read before the recent meeting in London of the Iron and Steel Institute, Mr. E. J. Ljungberg, of Falun, Sweden, referred to the extensive and costly trials which have been carried out at Domnarfvets during this and the past few years. The following is an abstract from Mr. Ljungberg's paper:—

For a country like Sweden, possessing practically no coal mines, but numerous waterfalls, the manufacture of iron and steel direct from ore by the agency of the electric current is of much more interest than the melting of pig and scrap to make steel.

In these experiments two modifications of a furnace, constructed by Mr. Wallin in Berlin, and several modifications of a furnace, constructed by Messrs. Grönvall & Lindblad (the Electro Metal Company), Ludvika, have been tried. Of these it is needless to describe any except the latest form.

The accompanying drawing shows a furnace similar to a common blast furnace, but with three electrodes fed by three-phase alternating current at about 40 volts, 60 cycles, and 9,500 amperes, averaging 674 horse-power, instead of tuyeres. In this furnace, which has been running for 1,903 hours, there have been produced 280 tons of iron, containing from 0.95 to 3.09 per cent. of carbon.

In the manufacture of this quantity there was used:—

	Tons.
Ore	442
Lime	24
Coke	41
Charcoal	58
Electrodes, total	6.5
Electric current (kilowatt-hours)	891,623

or per metric ton of pig-iron produced:—

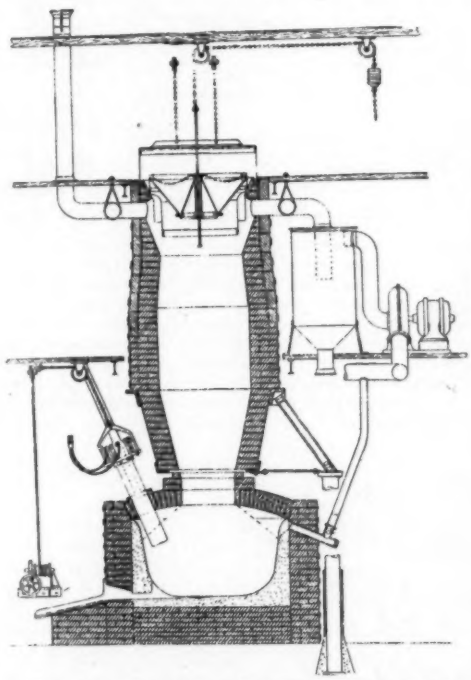
	Kilogrammes.
Coke and charcoal	353.3
Power, horse-power year	0.492
Electrodes, effective 8.8 kgs.	
Wasted ends 13.9 ,,	
	22.7
Pig-iron from ore and lime	60.02
Pig-iron from ore alone	63.50
Pig-iron per horse-power year	2.03 tons.

The temperature of the escaping gases from the furnace is generally very low, and they contain on an average about 22 per cent. of carbon dioxide (from 8 to 41 per cent.). The amount of carbon monoxide varies from 39.4 per cent. to 61 per cent. The gases contain practically no nitrogen, but steam from the water in the ore, lime, coke, or charcoal is present.

The efficiency of the electric current ought to be higher than hitherto, if the considerable loss of heat by cooling water and radiation can be reduced. These losses seem to be about 30 per cent.

No air whatever is used in the process, and the gases are produced from the carbon in the charcoal and coke and the oxygen in the ores ($FeO + C = Fe + CO$). Either charcoal or coke may be used, but the consumption of fuel will be practically the same in either case.

According to the description of the inventor, the figure shows a vertical section through the furnace, which consists of a lower portion or smelting chamber, corresponding to the hearth of a blast-furnace, and a top section or shaft. The latter is supported on columns, which prevent any weight from bearing on the arch of the smelting chamber. The latter is so proportioned as to provide a considerable amount of free space between the charge and the arched roof through which the carbon electrodes project into the charge. The brickwork is thus protected against any very high temperature, and remains a non-conductor of electricity. This is an important feature of this furnace, since experiment has shown that if the electrodes enter the chamber at the point where the charge touches the walls, a very high temperature is generated at this point; the brickwork is destroyed and becomes a conductor of electricity, giving rise to a more or less complete short-circuit. The brickwork may be further cooled by means of a blast of cool gas taken from the top of the furnace and blown in round the electrodes with a fan, no heat being lost by this proceeding.



VERTICAL SECTION OF ELECTRIC FURNACE AT DOMNARFVET.

The ore and fuel are crushed to a suitable size, and are fed into the top of the furnace through the bell hopper in the usual way, the ore being partially reduced by the carbon monoxide rising through the charge. The latter spreads out in the smelting chamber as shown, and the reduction is there completed. Since the electrodes project well into the charge, the highest temperature occurs in the centre

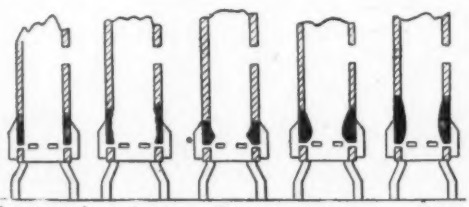
of the latter, and the brickwork is thus kept cool compared with the walls of an ordinary blast-furnace.

It will be seen from the figures given in the paper that a step has been taken in the direction of replacing a considerable part of the fuel used in making iron and steel by the electric current, and that the problem is technically solved. As regards its commercial value, it is too early to make any definite statement yet, but this will be readily understood by all iron and steel makers when they reflect how many years it has taken to bring the Bessemer, the open-hearth, and the basic processes to their present state of perfection.

Cupola Operation.

The following notes are taken from a paper read before the Engineers' Society of Western Pennsylvania (U.S.A.), by Mr. J. W. Henderson, and published in their "Proceedings":—

The mere melting of iron in a cupola is a simple operation. To get the highest efficiency out of raw materials and the necessary equipment, and convert these raw materials into metal most suitable for the work in hand, is another matter. An examination of a large number of plants shows some of the important factors to be as follows:—The relation of the receiving track to the ground and building plan, (this is important on account of storage room for raw materials, space for scales and narrow-gauge yard tracks, and means for properly handling the charges of fuel and iron); weighing facilities for the careful weighing of each complete charge as a separate unit; the elevator should be placed, in relation to the position of the cupola, so that the maximum loads of fuel and iron charges can be handled with the least interference with the operations on the charging floor;



Sections of Cupola Linings.

the charging room capacity in smaller foundries should be sufficient to carry the charges for the total heat, and in larger foundries adjusted so that the immediate cupola labourers will need the minimum assistance.

As regards cupola details, those of importance are:—Extension of the spout into the foundry; height of spout above foundry floor; depth of cupola from sand bottom to charging door; dimensions of charging doors and the distance between the doors and the charging room floor. The capacity of the cupola, when lined to its largest inside diameter with safety, should be always greater than the shop requirements, and with blower or fan capacity and adjustment within a range that will permit the melting speed to be as elastic as the needs of the shop may demand.

Cupola Linings.

There are five distinct outlines of cupola linings shown in the accompanying illustration. Eliminating the straight and the burned-out linings, as shown in Nos. 1 and 2, as regards which of the remaining three is the best, each of them may be said to be good under certain conditions. No. 3 will be found the most serviceable generally. It is very important where the point of the bulge is placed. If properly used, this bulge will prevent the bunging up of the tuyeres, daily patching of the lining, and will aid the temperature without materially reducing the melting rate.

The arrangement shown in No. 4 permits carrying a very thin lining above the bulge. It is also possible with this lining to carry iron bricks in the lining for several rows below the charging door. With this bulge and the thinner lining above it, the cubic capacity can be increased, the quantity of bed coke decreased, while reducing lining repairs and increasing the temperature of the metal. However, with this bulge the charges cannot be melted in their regular order.

The outline shown in No. 5 is the best for obtaining uniform temperature, oxidation, and melting. The dimensions should be maintained within one-half inch variation each day. This requires patching before each heat. There is no question but that the gain in quality of product is worth the trouble and expense. Only with this style of lining can accurate melting points be discovered after each heat that will indicate just how regular the charging has been done. Except for very long heats the melting point can be established by the method of burning the bed coke.

There are, of course, many modifications of the outlines; but it may be mentioned that, as a rule, too little attention is paid to the cupola lining and its effect upon temperature and the melting rate.

The Brandon Bridge Building Company, Limited, of Motherwell, N.B., have received the Government order for 127 monolith shoes for the foundations of the Rosyth Naval Base, near the Firth of Forth Bridge. These shoes are 40 ft. square, and are so designed that they will be filled up with concrete. They will be sunk about 30 ft. below the sea bottom. The total weight of ironwork for these shoes will amount to about 6,000 tons.

Geary, Adams & Company, Limited, of 25, Central Arcade, Wolverhampton, have been appointed sole agents for Birmingham and district for Davey, Paxman & Company, Limited, Colchester, manufacturers of vertical high-speed and horizontal low-speed steam engines for all purposes, boilers and superheaters, condensing plant, winding and hauling machinery, air compressors, traction and portable engines, gas engines and producer plants, etc.

Pipe Moulding.

By Arthur Greenhalgh.

Pipe moulding comprises not only straight and bend flanged and socketed pipes, but also tees, reducing pipes, thimbles, stops, etc., in a very wide range of dimensions. Standard or stock sizes of patterns are kept in most cases and are altered for jobbing sizes. Those for straight pipes and bends with flanges, sockets, etc., are kept, ranging, say, from 2 in. bore up to about 12 in. Except in the 2-in. size the patterns are of standard 9-ft. lengths, and grooves are turned at the end for the reception of flanges. Such patterns are made of wood and jointed; or if metal, unjointed, in which case they are let into joint boards to the middle plane. For lengths less than the standard a body flange is fitted. For lengths longer than the standard a special pattern is kept, or the standard one is lengthened by means of a dovetail, or by fitting the extra length over one of the prints. The standard pattern may be used for sockets and spigots. The sockets of wood or metal are screwed on to the pipe body, and the spigots are formed with strips of lead bent round and nailed. Branches are fitted when required at right or other angles by means of butt joints and screws.

Standard pattern bends are kept in stock, with flanges, sockets, and spigots, each being distinct patterns. They are seldom altered, but odd bends are kept for such work for flanged and socketed fittings, and for attachments to straight lengths of pipe when bends have to be cast with these. The bend lengths are attached to each other and to pipes with dovetails.

Tees are kept in standard and jobbing sizes both for flanged, socketed, and spigoted ends. The jobbing patterns are altered in respect of length, position and size of tees, for making odd connections.

Jobbing pipes are moulded by the ordinary methods of the foundry, and in common boxes. They are generally made by turning over. Box sides for straight pipes are often bevelled from the joint faces to lessen the sand space and amount of ramming required. Bends are moulded in boxes formed at suitable angles, and having bars to suit. Tees have boxes with branches, but when work of exceptional length and having branches at the sides, top, or bottom is required, any boxes are selected which happen to suit, and makeshift methods are adopted.

The cores for pipe work are made according to circumstances by all the methods of the coremaker. They are rammed up in boxes if the number is sufficient to pay for the boxes. Bends and tees are

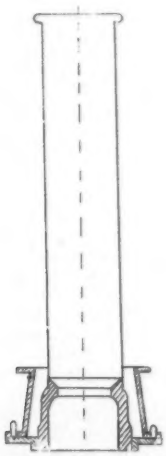


FIG. 1.—FIRST STAGE OF PIPE-MOULDING.

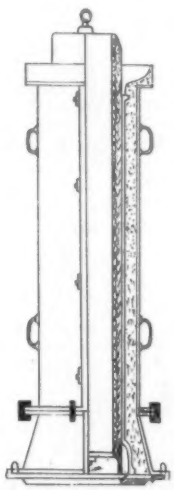


FIG. 2.—PIPE-MOULD COMPLETE.

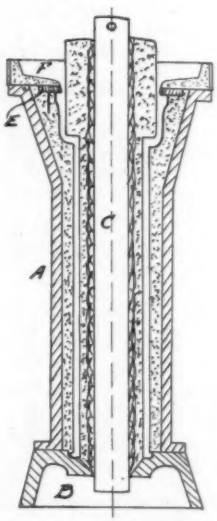


FIG. 3.—PIPE MOULDED WITH SOCKET UPPERMOST.

usually made thus, but cores for straight pipes are often, even though small, swept up in loam on a bar, and all large cores are so made. The bars are wound with hay-bands, and the cores are dried. Branch cores are butt-jointed to the main cores in the mould, and often also bend cores to the straight lengths.

Loam work is reserved for massive castings and for unusual sizes and shapes. Straight pipes and bends are both made in this way. The pipes are swept against a board and flanges or sockets fitted to the loam. Bends are swept with strickles against a guide iron. Sometimes the core is struck first and the pattern thickness added, and if numbers are required the pattern is made distinct from the cores. Loam work is of high value in this class of work. Though expensive, it is not so much as a pattern made in wood would be. There is no shape so difficult that it cannot be produced by strickles, guide irons, and thickness pieces.

Pipes are sometimes cast horizontally in small shops. The objection to this is the floating of scum on the top, where it is liable to lodge, and cause

sponginess and blow holes. This may be largely avoided by using risers, and by having hot, clean metal of a suitable grade. Another objection is the tendency of the core to rise about the centre, causing the metal to be thinner on one side than the other. The risk of this may be avoided by careful chapleting. But the free use of chaplets is undesirable in pipes which have to stand much pressure, as leakage often occurs round the chaplets. Hence, in the regular pipe foundries, the pipes are cast on a bank

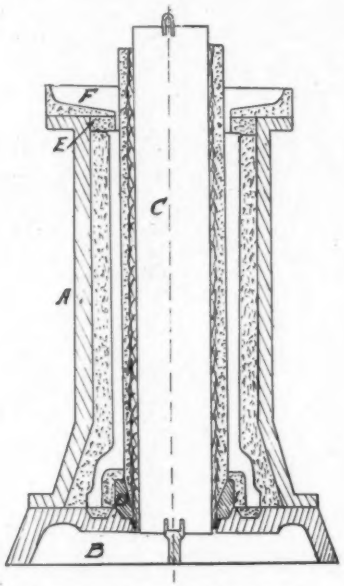


FIG. 4.—VERTICAL MOULDING; SOCKET DOWNWARDS.

having a slope of about 30 degrees to 45 degrees from the horizontal; or they are poured vertically. The first-named is still open to the same objection as horizontal casting, the second is not. The latter is therefore very general for both small and large pipes which have to be subjected to severe pressures. The cores are maintained in the centre, without chaplets, and the metal is of equal soundness throughout.

Figs. 1 and 2 illustrate one method of casting pipes vertically. The socketed end is laid face downwards, fitting within a ramming ring, and a portion of the moulding box corresponding with the socket is laid on the ring to which it is dowelled and rammed up to the joint face. The main body of the moulding box is then put over and rammed to the bottom of the bead ring. The ring is formed in loose segments round the body of the pattern. This is rammed, and then the print ring above, the box parts being clamped to each other. The main body of the pattern is then withdrawn, followed by the lifting of the main box. The socket pattern is withdrawn, and then the bead segments and print ring. The ramming ring is then removed and its place taken by a sand bottom.

The core is struck on a rigid barrel, covered with hay ropes and loam. The socket ring fits into the bottom plate; this portion is rammed into a core box. The barrel of the barrel core fits into the socket ring by a register of angular section. At the top the body core is encircled by a covering core. It is centred with a gauge and then wedged centrally by wedges between the main and covering cores. Figs. 3 and 4 illustrate the moulding of the smaller pipes vertically as practised in a well-known Philadelphia foundry. Both drawings show socketed pipes, but the socket is in the top in one case and in the bottom in the other. The parts are lettered as follows:—A is the moulding box body, made in one for the small pipes, but in two or three parts for the larger; B is the base which carries the mould; C is the core bar; D is the core ring on which the socket portion of the mould is rammed, and has a tapered bore by which the body core is centred; E is the bead ring which receives one-half the bead mould, forming the parting joint. In Fig. 3, where the socket is uppermost, the ring serves for centring the core only. The core is swept up on straw ropes, and the mould rammed round the pattern, and lifted away. Core and mould are dried in the stove, and returned to place, the mould closed, and the pouring basin F prepared and put on, the pouring being done in the pit.

The thicknesses of cast pipes are much in excess of those deduced by calculations. This is necessary on account of the uncertainties attendant on casting, and the liability of cast iron to crack under sudden shock. Pipes are generally specified to be of certain weight as well as thickness, to guard against thinning or thickening through the core shifting at the ends.

THE STIRLING BOILER COMPANY, LIMITED, of 25, Victoria Street, Westminster, S.W., have lately received several important orders, including the following:—Repeat order for two Stirling boilers, for the Indian State Railways (Oudh & Rohilkund Railway); ditto, for boiler for Copenhagen Tramways; ditto, for boiler, chain-grate stokers, and superheater for the Newcastle and District Electric Lighting Company, Limited; ditto, for boiler, superheater, and chain-grate stoker, for the Borough of Partick; ditto, for two boilers and superheaters, for the Fulham Electricity Works; order for boiler, superheater, and chain-grate stoker for Ashton-under-Lyne Electricity Works; order for boiler, fired with waste gases from destructor, for the General Post Office, Mount Pleasant.

THE Council of the Institution of Mining and Metallurgy have made the following awards for the past year:—The gold medal of the Institution to Professor William Gowland, who has recently vacated the Chair of Metallurgy at the Royal School of Mines, in recognition of his services in the advancement of metallurgical science and education during a long and distinguished career. The "Consolidated Goldfields of South Africa, Limited," gold medal to Mr. W. A. Caldecott for his work in the investigation of methods of reduction and treatment of gold ores. The "Consolidated Goldfields of South Africa, Limited," premium of 40 guineas conjointly to Mr. C. O. Bannister and Mr. W. N. Stanley in recognition of their work in the investigation of the thermal property of cupels, and for their joint paper on "Cupellation Experiments." Post-graduate scholarships of £50 each have been awarded to Mr. A. Haworth, Mr. J. Moore Samuel, Mr. C. Y. Bruce, and Mr. A. L. James. In addition to these scholarships, 18 graduates from British universities and mining schools have been selected by the Council of the Institution for post-graduate courses (with remuneration more than sufficient to cover the cost of living) in South Africa, India, Western Australia, New South Wales, British Columbia, Arizona, Brazil, and Portugal. These courses are of one and two years' duration.

British Foundrymen's Association.

Birmingham Branch.

The first meeting of the present session of the Birmingham Branch of the British Foundrymen's Association was held on Saturday, October 23, in the Birmingham Municipal Technical School. In spite of very bad weather, a large number of members assembled to hear the address of the new President, Mr. R. Mason. Since his election to the office in May last, Mr. Mason has left the John Wright & Eagle Range Company, of Birmingham, to take up the management of the Wigston Foundry Company, Limited, near Leicester.

The chair was taken by MR. F. J. COOK (Vice-President of the Branch and President of the parent Association), who expressed the hope that the coming session would be as enjoyable and helpful as the last. They all knew, he said, that their President, Mr. Mason, would do his very best to keep up the enthusiasm of the members, the excellence of the papers, and the high standard of the discussions. The members would notice that their programme was now issued with the programmes of all the other Branches, so that any member of that Branch, if he found it convenient, might visit one of the other Branches for any discussion in which he was particularly interested. He thought that would be an improvement upon their past arrangements, and he hoped would increase the interest in all their Branches. In conclusion, Mr. Cook announced an interesting programme of visits to works and other places during the coming session.

MR. HEGGIE presented the accounts for the past year, which showed an income of £14 14s., and a balance brought forward from the previous year of £2 0s. 1½d., making a total of £16 14s. 1½d., while the balance remaining to be brought forward this year was £2 3s. 4½d. This balance, he explained, had been handed over to the parent Association under the new rule, according to which all the subscriptions went to that body and all their expenses were paid from headquarters. He had, however, still in hand a balance of £5 10s. 9d. from the fund raised for providing tea at the University during the holding of the National Convention at Birmingham. The Chairman said that it had not been decided what to do with the latter surplus. They proposed for the present to retain it, and possibly might find some special use for it. If not, he supposed that too would go to the funds of the parent Association.

The accounts were unanimously approved.

The CHAIRMAN said that he had now to introduce, if that were needed, their new President, Mr. Mason. Fortunately, Mr. Mason was well known to all of them, and his enthusiasm in the work was a full justification for his election to the Presidency. (Applause.)

The PRESIDENT then delivered his address, an abstract of which is as follows :—

Presidential Address.

Gentlemen, I have long pondered over what subject I should deal with for my address. As I think a President's address should not be a technical paper, it seemed to me better simply to try to string together my ideas on the advantages of our Association and how it ought to be used by all of us to advance men and youths engaged in foundry work, to help them and to encourage them to raise themselves to better positions; to make all of them more efficient and more capable of guiding themselves and those with whom they associate, and any who may come under their charge. I hope I may present some of my ideas in such a way as to give a few of you some suggestion which may stick with you and encourage you in your endeavours to better your existence and forward the trade in which we all take so much pleasure, and at the same time earn our living.

Things are changing very rapidly in the foundry, and we must be alert to keep up with changing conditions. The day is nearly past for the foundryman who could take a day or a week off work because he was drinking, and have his place kept for him because during his steady periods he was a good workman. (Hear, hear.) I believe the time is also past, or nearly so, when a moulder on tramp could almost make sure of getting a job for a longer or shorter period in any town he called at. New patterns are designed for quicker and easier production, and moulding boxes are made for jobs which formerly were bedded in the floor or made in loam. Moulding machines are showing the Rip Van Winkles of the foundry the advantages to be gained, not from the moulding machine, but from the simplifying and production of good patterns made to suit quick methods of repetition. Moulders are also learning that with a better knowledge of the materials they use they need not tool certain moulds all over or sleek blacking or plumbago on them, but that they can produce quite as good castings of the articles they make by a judicious use of the properly mixed facings and core sands.

I believe we have also come to the time when the foundry will be kept more tidy and the moulders will be given a chance to clean the dirt from their hands and faces, and to change part or all of their clothing before leaving the works, and, what is very much to be desired, to wash before taking their meals. I admit that for a period considerably longer than the remaining part of our lives there will still be some foundries where there will not be such opportunities, but I am sure that the advanced employers will see that it is necessary to do this voluntarily, and will do it soon, and before the Government steps in and makes it compulsory. By doing this voluntarily they will secure the pick of the best men.

Good workmen do not always make employers good, although they are sometimes able to compel bad employers to concede necessary appliances. But good employers are able to make better men of their workmen by considering their needs and acting accordingly. Let those employers who have any good in them come into the foundry at 6 o'clock on a cold, wet morning, pick up the rammer, handle the boxes and the water-brush or swab, and mix and put on clay wash, as some of the boys are doing to-day. Let them keep at it until breakfast-time, then sit down to breakfast in the cold, draughty foundry after washing their hands in cold water, and drying them by wiping them on the hips of their trousers, as thousands are doing every morning in Britain. Let them then consider well whether, as some say, it is better for these lads, and hardens them. Would they consider it a good training ground for their sons under these conditions? If so, let them send

them there; if not, let them help to make it better by giving facilities for washing, and a dining room where men and boys can take their food under decent conditions. (Hear, hear.)

Of course, a great deal can be said on the employers' side as well. At the present time, we all know there are hundreds of employers who can hardly make a profit at all, and having a foundry cannot let it go because if they did so they would lose all their money. These, of course, could not provide the facilities mentioned, and we know that hundreds of foundrymen are not ready for these things if they were provided. But surely a similar thing could have been said at one time of the employés of firms in other trades who have supplied these things and have found that with experience of such advantages their employés altered in their habits.

There is also the question as to whether the workman does all he can to give adequate service for the wage he is paid. We all agree that there are large numbers who consider that however little work they do it is too much; but we know that these men are the minority. We know that, taken as a whole, British workmen are good honest workers when properly directed. (Hear, hear.) In a large number of cases where good results are not being got we see the reason for poor results in the wages and the privileges (or want of them) of the foremen and charge hands. These directors and planners, when given adequate wages and security of employment and treated as valued servants, can, and do, get results. They find their work a pleasure, are always planning cheaper and better ways of manufacture, and get the best out of their workmen; but when these men are not treated properly, then the workmen scamp their work, because they are not under the guidance of capable heads. Some employers will probably question this, and hold that the foremen are quite as bad as the men they govern. My advice is, "Avoid such employers." It has become as necessary to know an employer's character as it is for an employer to know the character of his employé.

We are an educational body, and our members surely will not refuse to help to make our Association aim at producing better citizens as well as better foundrymen. The power we have of influencing those with whom we work should never be lost sight of. We must not forget that we all owe something to those with whom we are associated, whether they are our superiors or inferiors, whether teachers or taught. Foundrymen of the present day, as a whole, are undoubtedly superior to those of 30 years ago, and future foundrymen will be superior to us. It is our duty to posterity to endeavour to raise superior men.

Now, how can that be done? We are doing part of it by being members of this Association, for the encouragement of foundrymen who make research into the problems of our vocation and who, by their reading of papers, and in discussing the papers of others, tell us what they have discovered or experienced. We may not get just what we want, but we all have benefited by something or other which has cropped up in our Association, and which has opened up to us a new way of looking at a thing. How often, too, have we, because of our meeting with one another, been able to tackle confidently problems and more satisfactorily dispose of them than if we had never met.

We should also present to aspiring youths the reasons, drawn from our own experience, for our failures and our successes, and show those under us how they may raise themselves from the lower positions to the higher. (Hear, hear.) We can give them some idea of what others have done to get higher, and we can also tell them of the causes of failure, so that they may avoid certain mistakes. I think—although most of us like to forget our failures—that our failures and the failures we have witnessed are often better guides than accounts of successes.

To come to the question of learning, the trade of moulder, pattern-maker, designer, or engineer can, of course, only be learned in the works, but it is not sufficient for any of us to learn our trade only. We must have some knowledge of allied industries, and of the sciences which are taught in the schools, such as mathematics, physics, and some acquaintance with hydrostatics, mechanics, with chemistry, and, above all, mechanical drawing. The day is approaching swiftly when a man will be refused an appointment as foreman in the foundry trades if he has not a fair knowledge of the metallurgy of iron and steel.

The man who seeks for improvement will also learn what he can of business methods and book-keeping. He should be able to appreciate his employer's reasons for requiring exact costs on work done and to realise that his employer's part of the business is not all dressing well, drawing large profits, and complaining of the state of trade. Anyone who desires to rise in his profession must prepare himself as he goes on for each step upward. The apprentice must do his part of the menial job; it is part of his lesson. But he must be taking his share of all other work given to him and remember that he cannot have the jobs he would select himself and which he could have pleasure in doing, and that his part of the responsibility is to do his best on the work that is given him, remembering meanwhle that he who cannot obey cannot give orders. The journeyman who desires to advance must not be afraid he is doing too much for his wage, because none of us can ever be paid the full value of our work; otherwise, there can be no profit for capital. If any man is doing 30s. worth of work only for a 30s. wage, then that man is useless to those who employ him. And any employé who is drawing 30s. per week and earning less than 45s. is a direct loss, and so on *pro rata*. Therefore, there must be no holding back by the man who intends to rise. He must do his best all the time for those who employ him. (Hear, hear.) He must, out of working hours, do nothing that will make him less fit for his daily employment, and he must reach out to better himself. He should not be satisfied to wait until he is offered an advanced position. He must reach out after it, he must show those over him in a becoming but firm manner that he is suitable to lead and direct. No proper foreman or manager will then overlook him when the occasion occurs for advancement. But, of course, he may be under a foreman or manager who is not proper, and is jealous of his ability, and who feels that he dare not advance a capable man without jeopardising his own job. Then the capable man must begin in another shop; he should not remain, though that advice may seem hard to follow.

It is difficult to do anything that is worth doing; the easy things can be done by anyone, and therefore it is not remunerative to do these things. He who wishes to advance must work and plod. The craving after an easy, comfortable living must be subdued. Study the lives of men who have made their mark on the progress of the world, and we see the struggle they had to overcome their inclinations at times. We have to do the hard, the difficult things, and leave the easy ones for those who would rather remain in the rut than make the effort to lift themselves. When you have got your first position of charge over the production there must be no sitting down to it. It requires more, and harder

application! You must make every effort to do all that is entrusted to you in the best possible manner, and at the least possible cost. But, at this point, let me warn you against a mistake frequently made by young men in new positions of charge. A young man is bent on doing better than the man before him, and, as a rule, has confidence in himself and his strength, and little reverence for the way things are done at present, or for the men who are doing them. As a rule, he thinks that the way he knows is the best way. Old men are quarrelled with and turned out. I hold that no man should be turned away until you have tried to teach him your methods and to educate him. It is your privilege to encourage and raise men up, and your disgrace to throw down any man who is willing and capable of being taught. (Applause.) Apprentices are used to reduce prices, and often no care is taken to teach them a trade. They are put to do special work, at which they become as efficient as men, and as long as they will do that work for a boy's wage, they are kept doing it. But when they ask for a wage commensurate with the time they have been there and with the age they have attained, they also are cast out, and more youths brought in to follow in due time their predecessors.

Now, these are the mistakes men make regularly in their first position of charge, and some—those who have no ability to invent new methods or to apply old methods to new work so that it may be made faster—keep on with this. It is the only justification to their employer for employing them, and often their employer is as bad as themselves, and is afraid to lose such a man in case he might get a foreman who would not do such a thing. That foreman and that employer think that the youths whom they have turned away are no concern of theirs, and that no one has any right to blame them for what may become of these youths. But they are making wastrels of those who should be made good citizens and capable workmen. It is our duty to manufacture goods better and cheaper than ever was done before, and our Association is a help towards that; and we must be ever on the alert to discover and apply all the methods we can to that end. But we must either restrain ourselves or be restrained by the rest from dragging the nation on to its knees for the sake of the few pounds which can be earned by this dirty work. The right men are beginning to speak out against it, and as an educational Association we must range ourselves on the side of the national good. (Applause.)

The man who is able and is getting good results should be encouraged. He should be granted privileges which will not be granted to the standstill, and the employer, manager, or foreman, who is not able to give these privileges to the one and withhold them from the other should only have the one class of servants under him. All will be one dead level of mediocrity in that firm. Heads of firms must realise that to get the best results they must back themselves up with best men, as well as the best plant. Plant and machinery are no good without the right men. Imagine our Navy with its "Dreadnoughts" and its guns without the men behind them, and you will see the best plant is useless without the best men; and the best men are hindered if not supplied with the best plant.

There will always be openings for good men, but you must seek these openings, and when you have found them you must take care that your employer knows that you are getting results. This is more difficult because in numbers of our limited companies to-day you cannot come in touch with the head, and the man, or men, between you, if bad, can keep you where you are and can strangle all the initiative you have. Where this is the case, you will require to move. My advice is: Act straight, help your fellow man, and remember that the failures of men serving under you are your failures; turn no willing, honest man out as a failure till you have made sure that his failure is not due to your inability to teach him, remembering, meanwhile, the mistakes you have made and are prepared to risk making, and remembering your duty to your nation, your employer, and those dependent on your successful management of the trust placed in you. (Applause.)

Comments on the Address.

The CHAIRMAN said they had listened to a very interesting address ranging over a very wide field. Presidents' addresses were privileged against discussion, but there were one or two points to which allusion might be made. Their President had spoken of the means and facilities for washing and taking meals in the foundry in the proper way. Unfortunately, there were very many foundries in this country which were not fit to work in, let alone have meals in. On the other hand, men did not always use the opportuities they had, and the men themselves seemed to want educating in the use of these facilities as well as the masters in giving them. (Hear, hear.) He had had the privilege of installing means for washing in the foundry with which he was connected, hot water being provided. He did not expect much result from this, but he was surprised at finding the extent to which the men used hot water for washing. They even went so far as to have a shower bath. This had been very encouraging to him, and it had so impressed the firm that they had spent something like £80 in providing further washing accommodation. These facilities were being used more and more, and he was sure it paid the men and the employers as well. Professor Turner was a great advocate of that sort of thing, and had often spoken of the refreshing influence on a man of a wash after working hard in the foundry. He (Mr. Cook) could bear this out from his experience, and he recommended it to all who had not tried it. With regard to the education of apprentices, no doubt many a man who had youths under him, when he found a boy quick at a certain kind of manual work was tempted to keep him at it, but if a boy in his early days showed ability and interest in his work, it would pay in the end to give him some attention. (Hear, hear.) Nothing could be more satisfactory to the foreman than to find a boy at the end of his time coming out as a first-class workman. It was a pride both to the foreman and to the boy. He had had foremen who took this interest in the boys and liked to see them pushing on and attending the technical school, and trying to qualify themselves for higher positions. Some of the boys who did not make much progress no doubt thought that those over them were always grumbling, whereas the latter as a matter of fact merely wished to do the best they could for the boy. (Hear, hear.) He had always found that a foreman who took this line was well repaid for his trouble. As to the handling of men by the foremen, unquestionably there were very few who were bad workmen where they had the necessary attention paid to them. When the foreman was a capable man there were very few men who could not be got to do a proper day's work.

PROFESSOR TURNER, in proposing a vote of thanks to the President for his address, said he thought Mr. Mason had justified his selection of a theme, for he had given them ideas which were distinctly uplifting. He had given them an ideal of the nobility of work, and of the character which a man should have in order to succeed. He thought that if they could get men to conform to

the general principles which Mr. Mason had laid down they would not merely get good foundrymen but also good employers and good foremen. The same principles, however, were applicable practically to every trade in the country. He had been smiled at sometimes when speaking of workmen washing after they had finished their work. It had been considered by some rather a fad, but he felt that it was an important question. First, it was a question of health, then there was the question of the self-respect of the individual. The question of the training of apprentices was, as Mr. Mason said, very important. Too many young people were treated merely as tools out of which as much work was to be got as possible, or as sponges to be thrown aside when squeezed dry. Whatever might be their duty towards the older men, who might be capable of looking after themselves, everyone who employed young people should, as far as possible, act with a view to their future welfare. (Hear, hear.)

Mr. A. H. Hiorns, in seconding the motion, said it had been surprising to him many times when he thought he had studied a certain subject and knew it thoroughly to find someone else, who perhaps had not given so much thought to it, able to give him a few straight tips, which helped to elucidate the matter. They could not live to themselves, and a man often failed because he tried to do everything and get everything for himself. In that way, he lost three parts of the good which he might have got by trying to help his fellow men and being helped by them. He was very much struck by the extent of the scheme of scientific training which Mr. Mason had suggested for the foundryman. He was afraid they would have to wait very many, many years before they had the ordinary foundryman well up in physics, mathematics, chemistry, mechanical drawing, and so on. All these things were exceedingly good in their way. Very often it was said that a little knowledge was a dangerous thing, but to be a successful workman it was not necessary to know a great deal about some things, though it was very important to know a little about essential things, and it was of the utmost importance to know everything that could be known about one thing. He was very much interested by the able way in which Mr. Mason dealt with the duties of master and man. At first, when Mr. Mason was talking about the masters, he thought that what was said would be appreciated by all workmen, but when the workmen's turn came, he found that a great deal more was expected of the workman than even of the master. Coming back to the subject of education for apprentices, he did not see why that Society should not bring pressure to bear on the authorities of the Birmingham Technical School to institute a course specially for foundrymen. He did not mean simply a course in metallurgy, but a course in those subjects which Mr. Mason had mentioned, which, if not essential, were extremely important. In many foundries, as in all works, there was a great deal of waste, and he thought their future success would depend very largely upon reducing this waste, or in being able to utilise what was now waste for beneficial purposes. He believed that in many trades this reduction of waste or the utilising of waste had been the means of bringing large profits into works which otherwise would have had to go on at a loss. One illustration was that of the manufacture of basic steel. He understood that if it were not for the utilisation of the slag, many works would have to be carried on at a loss. He strongly commended this question of waste to their consideration. It was also of the utmost importance that every workman should aim at being himself at some time or other a master. He knew they could not all be masters, but it would be a good thing if they all aimed at it. (Hear, hear.) He "Shoots higher far, who aims a star, than he who aims a tree."

They should all aim at being something a good deal better than an ordinary workman. If Mr. Mason had only succeeded in teaching them the great principle of exercising the mind upon things with which they came in contact from day to day he would have accomplished a very great thing for them as members of that Association. (Applause.)

The Chairman referred to a remark of Mr. Hiorns in regard to a course for apprentices, and said that perhaps Mr. Hiorns was not aware that when they had their Convention in Glasgow they saw a very good example of that sort of thing being done by Professor Sexton. Afterwards, his firm approached the Birmingham Technical School and something was done to which each year a little had been added. They had now at the School a little foundry worked by a practical moulder, and a good deal was done in that respect. The School did not as yet go the "whole hog," but they must keep pushing along till they got in Birmingham what Professor Sexton was doing in Glasgow, where the pupils were given a little mathematics, drawing, and science before going on to the practical part.

Mr. R. Buchanan supported the motion, and said it gave him very great pleasure to see Mr. Mason in the Presidential chair, and to hear from him an address which had the great merit of bringing forward something new. He agreed with Mr. Hiorns that it was not possible to place their ideals too high. He was glad to hear what Mr. Mason said on the influence of those in charge upon those whom they were bringing up. Foremen and others in charge did not realise sufficiently the enormous unspoken influence they exerted.

Mr. Mason, replying to the vote of thanks, said that in speaking to them he had endeavoured to speak also to an audience outside those walls. When in the North of England on his holidays, he was surprised to find himself being tackled on things which had taken place at their meetings in Birmingham. They might think that when they met there they were only helping themselves, but he found that the subjects they discuss there and their discussions were read very widely, and evidently were useful to others as well as themselves. He had borne that in mind when preparing that address, and he hoped that they would all bear in mind that when they met there they were helping not only themselves but others who, like them, were trying to better themselves and the trade in which they were interested. (Applause.)

Mr. W. T. MacCall, of Halifax, has been appointed principal of the electrical engineering department at the Sunderland Technical College.

The late Mr. N. J. West, engineer, a director of Harvey & Company, Limited, Hayle, Cornwall. left estate valued at £29,239 gross, with net personalty £21,336.

The New Yard Iron Works, Workington, recently run by Kirk Brothers & Company, Limited, and latterly in the hands of T. W. Ward, Limited, Sheffield. have been sold to Raine & Company, Limited, iron and steel makers and merchants, of Pilgrim House, Newcastle-on-Tyne, and Winlaton Mill and Delta Iron Works, Derwenthaugh-on-Tyne.

Correspondence.

Mixing Cast Iron and Steel to Get Dense Castings.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—On page 594 of the October number of this Journal, you deal with a German iron produced by a mixture of iron and steel, which, to judge from the analysis and the various statements, should be regarded as a substitute for our English cold-blast iron. It would be interesting to have the opinion of practical foundry engineers regarding the actual value of cold-blast irons such as C. B. Blaenavon or C. B. Dud, so well known for cylinder castings. As a matter of fact, it is astonishing that such highly priced cold-blast qualities are still finding a ready market, considering that the use of steel scrap is more and more advocated for obtaining a dense and close grain, as well as a great transverse and tensile strength. But, after all, are these the only physical properties necessary for a good cylinder metal?

Years ago French foundries made a regular practice of melting a charge consisting of scrap iron and scrap steel or pig-iron and scrap steel, casting the metal into pigs in order to use these as additions to the cupola charge for obtaining dense and strong castings. The use of "lingotage" in France is diminishing more and more, and no doubt the French iron-founders have their reasons for this. The addition of steel to a cupola charge, especially if not treated very carefully, has great drawbacks, owing to the enormous shrinkage of the metal and the want of soundness in the finished material, this latter being due, in a large measure, to the great quantity of gas which steel is apt to occlude. This gas makes blow-holes, and it would be necessary to ascertain whether the German alloy mentioned by you is without the defects which always accompany an addition of steel. The addition of steel, although closing the grain of the iron, very often gives a "short" metal, and the strength of the casting is therefore uncertain. Further, the addition of steel has to be very carefully handled in order to avoid the hard spots generally found in such castings, and a very unreliable structure.

In the article in the October number there are several statements which are more or less theoretical. The percentage of total carbon is strongly emphasised. At the beginning it is stated that by adding steel to the cupola charge for the purpose of getting a dense casting, great uncertainty results, principally from the high melting temperature of the steel, "which must first gain carbon in the furnace and melts more slowly than the pig." There is, however, no allowance made for the alloy which contains carbon of 2.34 per cent. absorbing carbon when passing through the cupola. The calculation of the carbon in the mixture of 70 per cent. of ordinary pig with a carbon of 3.6 and 30 per cent. of the alloy with a carbon of 2.34, with a resultant carbon of 3.22 per cent. should therefore be considered with care. It is not always possible to remelt cold-blast iron in a cupola without the metal gaining carbon. Now, it has to be considered that a cold-blast iron, being a product of first smelting and smelted from the ore, should really be saturated with carbon, through having previously been in contact with the fuel.

The alloy of iron and steel invented by Henning has been advocated in Germany at meetings of foundry experts, and in technical papers for several years, and according to statements from German sources, this metal was patented in Germany in 1905. The fact that four years were required to bring the matter before the English public in such a way, seems a doubtful testimonial to its adaptability. But above all, what are the merits of the invention, considering that the mixing of iron and steel has been in practice for many years, and is still actually practised and discussed in technical papers?

Yours, etc.,
"RDS."

The Making of Solid Valve Castings

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—In the last number of this Journal, on page 624, were given some particulars respecting solid valve castings, giving an apparently very suitable mixture for valve castings with American pig-iron. This article refers essentially to American practice, and we would like to remind the readers of the FOUNDRY TRADE JOURNAL that we have been making for the last 25 years a speciality of pig-iron for cylinders, valves, and similar castings, and that a Frodair mixture, No. 72, consisting of 40 per cent. special pig-iron "Frodair Cylinder," 30 per cent. special pig-iron "Norrfield," and 30 per cent. strong machinery scrap, yields an entirely similar analysis to that quoted, while the mixture is also, on account of the well-known physical properties of Frodair brands, a very convenient material.

Yours, etc.,
THE FRODAIR IRON AND STEEL COMPANY, LIMITED.
Fenchurch House, London, E.C.

Queries.

Slag Troubles.

Our cupola has an internal diameter of 24 in., and is of the Collard pattern made by Byrem & Company, Detroit, U.S.A. It has two rows of tuyeres, but we seldom use the upper ones. The coke bed is maintained about 2 ft. 6 in. above the bottom tuyere holes, or 12 above the top. We use Derbyshire gannister for lining the furnace, and employ a good brand of pig. We have tried rumbling our scrap-iron to entirely remove rust or sand from it. The cast does not usually exceed 2 tons, and we usually hold the blast at about 6½ in. But we have very much trouble with the slag blocking up the tuyere holes and coming out of the tapping holes and trough, and also accumulating round the edges and lips of the ladle. Until recently we have had no trouble whatever with the slag, and we are at a loss to know what is the cause. We have a new furnace man operating the furnace, and have also changed our coke. Can any of your readers advise us in the matter?

"PLOUGH."

THE BRITISH WELDING COMPANY, LIMITED, of 25, Victoria Street, S.W., have secured an order for 55,000 ft. of welded steel tubes from the Esquimault Works Company, of Victoria, B.C. Delivery is to be begun next March, and the whole quantity of the pipe is to be laid down in Victoria by June 1. The pipes are to be made of steel 5-16 in. thick, and the largest are to be 2 ft. 6 in. in diameter. The company's works are at Motherwell, N.B.

Inventions.

Applications for Patents.

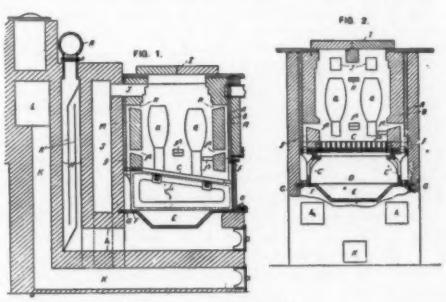
An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

21,419. Carburising iron or mild steel in iron alloys. W. R. Hodgkinson, 89, Shooters Hill Road, Blackheath, London.
21,612. Metallurgical furnaces. L. Ruthenburg.
21,887.*Machines for use in drawing patterns in moulding. W. O'Keefe and S. Strettles, 55, Market Street, Manchester.
22,608. Sand moulding machine. R. S. Buch.
22,743. Treatment of iron or steel to prevent oxidation. "Coslett" Anti-Rust Syndicate, Limited, and T. W. Coslett.
22,834. Foundry moulds. W. Zimmermann and E. Moehrlin, Norfolk House, Norfolk Street, Strand, London.
23,002. Furnaces for the melting of metal or scrap. C. Nicholas and B. G. Bateman, 19, Hanover Square, London.
23,381. Furnaces. S. Walton.
23,435.*Welding furnaces heated by gaseous or vaporous fuel. J. Wolf.
23,439 & 23,440. Purification of magnesium and magnesium alloys. (Chemische Fabrik Griesheim-Elektron, Germany.)
23,441. Manufacture of dense castings of magnesium or magnesium alloys. (Chemische Fabrik Griesheim-Elektron, Germany.)
23,534.*Regenerative gas re-heating furnaces. F. K. Siemens.
23,536. Metallic alloys. J. F. Duke.
23,594. Core-making machines. G. Buchanan.

Abstracts of British Patent Specifications recently accepted.

25,035 (1908). *Copper and its Alloys.* Communicated by the Titanium Alloy Manufacturing Company, 15, Wall Street, New York, N.Y., United States of America.—It is well known that copper, when melting, absorbs gases, and is oxidised, to an extent, during fusion, the resulting oxides dissolving in the metal. The result is that copper cannot be cast in sand directly from crucibles, or in sand moulds made in flasks, or such moulds as are used for casting pig-iron, copper so cast containing "blow holes" and cavities to such an extent as to render it, for instance, unfit for drawing into wires without special manipulation and treatment. But if to copper, when charged into the crucible, or while melting, there be added a small quantity of titanium, for instance preferably from 1 per cent. to 2 per cent. in weight of an alloy of copper and titanium, containing say from 5 per cent. to 12 per cent. of titanium or thereabouts, the molten mass can, with advantageous results, be cast in sand in flasks such as mentioned above, the pouring being quiet, without overflow through the gates, and without piping, and the resulting bars solid, presenting in practice a close-grained, dense, structure free from blow holes, and undesirable oxides. For example: The copper to be treated is melted as usual in the crucible or other container. There is then added thereto an alloy of copper and titanium, which addition, in many cases, need not exceed from 1 to 2 per cent. of the entire weight of the copper treated thereto, and the amount of titanium, 5 to 12 per cent. of the said addition, the function of the titanium, when added in such small proportions, being limited to the prevention of the formation of gases, oxides, or other undesirable compounds with the copper, and the elimination of those already contained therein, and the titanium being, in such cases, so proportioned as to enable the process to result in a final product without undesired gases, oxides, or other compounds, or resultants thereof, and with also substantially no, or traces only of, titanium. The effects of said process are also advantageous in cases in which the molten copper is intended to form the basis of alloys of that metal with zinc, or tin, or both, including also additions of lead or manganese, as practised for brass, bronzes, and such special copper alloys, the resulting alloys derived from copper so treated being also substantially free from blow holes, and generally superior. In the production of such alloys the titanium may be introduced into the molten mass composed of all the constituent metals, or preliminarily as aforesaid into one or more of said constituent metals, copper, zinc, tin, etc. It is to be understood that the titanium hereinbefore referred to is titanium in its elemental or metallic state as distinguished from compounds of that metal, such as its oxides, etc.

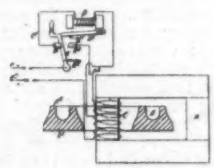
12,534 (1908). *Crucible Furnaces for Melting Steel.* W. Miller, 240, Lockhurst Lane, Foleshill, Coventry.—Figures 1 and 2 are vertical sections at right angles to each other of a crucible furnace constructed in accordance with the invention. The furnace may be of ordinary form, having a metallic casing A with fireclay lining B, and bottom grate C, with supporting brackets C^1, through which grate the heated air has access and the ash from the fuel drops into an ash-pit D below. The bottom of the ash space is formed by a water tray or trough E, having a projecting flange F resting on the brickwork setting of the furnace, and formed with perforations or openings G in conjunction with perforations or openings in the brackets C^1 for the passage around it of the heated air, which is drawn through the branches *h* of a regenerator flue H in brickwork at the



Miller's Specification.

rear of the furnace and passes up to the under-side of the furnace grate C, and passes up to the upper side of the grate C by passages *f*, f^1, and ports f^2, f^3. The hot waste gases from the furnace, which is closed by a cover I, escape to and through a waste gas flue or flues J, K, contiguous to the air flue H, and thence to a main flue L leading to the chimney, so that the air supply is heated. The crucibles Q (Figures 1 and 2) placed in the furnace may be of ordinary removable form, and may rest on a support on the bottom grate C as is usual. By the arrangement described the regeneration of the air is continuous, and increases in intensity as the flues become hotter. A high temperature can be attained in a short time and thereafter maintained, while great saving of fuel is effected by the introduction of supplemental air to consume the gases in the furnace which would otherwise go to waste.

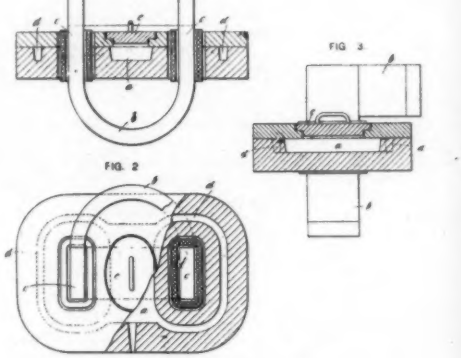
8,194 (1909). *Electric Induction Furnaces.* The Grondal Kjellin Company, Limited, and J. Härdén, 20, Abchurch Lane, London, E.C.—The accompanying cut illustrates a simple form of electric induction furnace. A is the annular melting chamber, B the closed iron core, and C the primary winding. The quantity of fireclay or other binding material employed may vary in accordance with the nature of the charge undergoing treatment; the proportion may, for instance, vary from about equal parts of binding material and graphite to almost pure graphite containing only a very small percentage of coal tar, molasses, or the like, the latter being used when treating a charge having a very high melting point. In order that the heating of the melting chamber walls of the electric induction furnace may be chiefly confined to the portions with which the charge is in contact, the base or lower portion A^1 of the melting chamber or lining may be thickened or enlarged, so that by reason of the comparatively greater sectional area of the aforesaid base or lower portion, as compared with the lips or upper parts A^2 of the walls, the induced current flowing in the aforesaid base or lower portion A^1 will be far stronger than the current in the lips or upper parts, the induced current being distributed in accordance with the sectional form or shape of the melting chamber or lining. The physical properties of the constituents of the melting chamber or lining and the proportion in which they are mixed are preferably such that the total electrical resistance of the chamber or lining is fairly high compared with that of the charge



Gröndal Kjellin Company's Electric Induction Furnace.

when in a molten state. The result of this is that as soon as the charge becomes molten, forming a complete circuit, nearly all the induced current will flow through the charge in preference to the chamber walls because of the comparatively low resistance of the charge. The melting chamber walls are then relieved from being heated otherwise than by the conduction of heat from the molten charge. To ensure or assist in the transference of the induced currents from the melting chamber walls to the charge itself, means may be provided to vary the inductive effect of the iron core, the latter being strongly excited while the furnace is being started, so as to force the induced current through the high resistance of the melting chamber walls, and less strongly excited when the charge is molten so as to avoid the intense current which would otherwise flow in it by reason of its comparatively low resistance. One method of obtaining this result is to connect the primary coil C to a source of constant voltage, and to subdivide it or tap off a portion and provide means whereby a portion only, say from one-third to one-half, of the windings is in circuit until the charge has become melted, the whole of the windings being then connected in circuit.

18,513 (1908). *Electric Induction Furnaces.* Röchling'sche Eisen-und-Stahlwerke Gesellschaft mit Beschränkter Haftung, and Wilhelm Rodenhauser, 58, Poststrasse, Völklingen on Saar, Germany.—This invention relates to electric induction furnaces of the kind in which one or more of the limbs of the closed iron core, on which the primary winding is wound, are surrounded by continuous melting channels containing the material to be melted in such a manner that the current for melting is produced directly by the induced currents set up in the material to be melted, which serves as a single secondary winding. Owing to the relatively great distance of the secondary winding (the material to be melted) from the iron core, great magnetic dispersion is produced. The chief object of the present invention is to reduce the dispersion by means of a special formation of the cross-section of the limbs or members of the closed iron core, and a novel arrangement of the members composing the said core. This arrangement is based upon the fact that a far greater number of lines of magnetic dispersion issue from the limbs at the two faces that are formed by the edges of the compressed sheet metal laminæ composing the limbs, than from the faces formed by the two outer sides of the two outermost sheet metal laminæ. The dispersion is reduced by making the faces constituted by the outermost sheet metal laminæ considerably broader than the faces formed by the edges of the compressed laminæ. Fig. 1 of the accompanying illustrations is a vertical section, Fig. 2 a sectional plan, and Fig. 3 a vertical section at right angles to the position in which Fig. 1 is taken, illustrating one form of furnace constructed in accordance with this invention. *a* represents the common melting



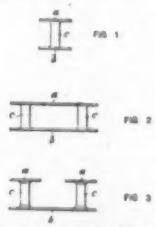
Electric Induction Furnace.

chamber or hearth formed by the union of the melting channels *d* which surround the vertical limbs *c* of the closed iron ore. The vertical limbs *c* are connected together by the yoke pieces *b*. In the particular construction of furnace illustrated it will be seen that the furnace is about one and one-half times as long as it is wide, and that the width of the laminæ of which each of the limbs *c* is composed is about three and one-half times as great as the thickness of the assemblage of laminæ. The upper of the two yoke pieces *b*, which are bent semi-circularly and connect the ends of the limbs *c* as shown, is arranged in such a manner that it lies in a horizontal plane, with the result that free access can be had to a working door *e* arranged in the middle of the furnace cover and serving for the introduction of fluxes or the like into the melting hearth *a*. The lower of the two yoke pieces is arranged in such a manner that it lies in a plane containing the longitudinal axes of the vertical limbs; by this arrangement the lower yoke piece *b* and the two limbs *c c* may consist of one piece as shown.

9,383 (1908). *Manufacture of Steel and other Metallurgical Processes.* A. Reynolds, 11, Queen Victoria Street, London, E.C.—This invention relates to metallurgical processes which, in order to promote or complete desired reactions, are conducted in crucibles of fire-clay, etc. In such processes the crucible from the metallurgical point of view may be regarded functionally as a solid slag, and the present invention may be said to consist in increasing the mass and surface of such solid slag in contact with the charge by providing the crucible with a lid having rods depending into the charge, such lid and rods being of the same material

as the crucible lining, or of a material of equivalent character. If the reaction to be promoted is an exothermic one, it may be sufficient to pour the melted charge into a crucible fitted as described, the crucible and lid having been previously heated, but should the reaction be an endothermic one, prolonged heating may be required, and the crucible is in this case heated externally, electrically or otherwise.

25,050 (1908). *Core Support or Chaplet for Foundry Purposes.* O. Rieck and A. H. Melzian, trading as Rieck & Melzian, 2, Goldbeckplatz, Hamburg.—The separate parts of the metallic core-supports are welded together electro-thermically; there then remain at the points of connection no intermediate spaces, and an intimate connection of the cast metal with the core-support is assured. The electric welding may be effected by submitting the parts to the action of an electric arc, or the separate parts to be connected may be utilised themselves as electrodes, the spaces between the separate parts serving for the formation of the electric arc, so that an intimate welding of the parts to be connected together must take place. Figs. 1 to 3 show various examples of core-supports made in accordance with the invention. According to Fig. 1 the core-support consists



Core Support or Chaplet for Foundry Purposes.

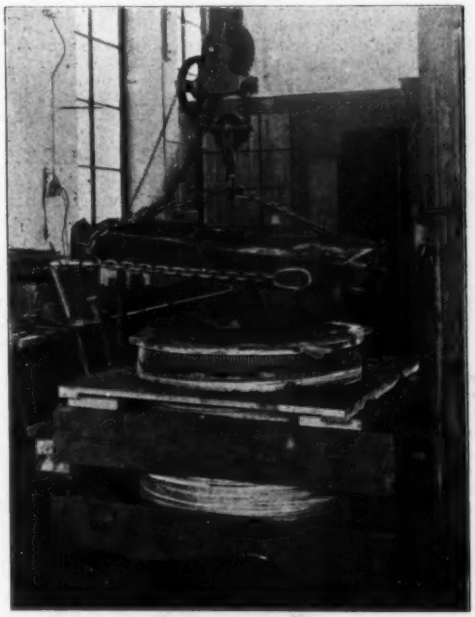
of two plates *a* and *b* and a stem *c*, the ends of which latter are welded to the plates by electric welding. Fig. 2 shows a core-support in which the two plates *a* and *b* are electrically welded to two stems *c*, *c*. In the construction shown in Fig. 3 two plates *a* are welded electrically to a single plate *b* by the stems *c*, *c*.

24,007 (1908). *Preparation of Iron or Steel for Casting.* Chemische Fabrik Griesheim Elektron, 51, Gutleutstrasse, Frankfort-on-the-Maine, Germany.—The inventors have found that magnesium should be introduced into the iron or steel when the metal forms a semi-fluid, or thickish, mass in passing from the solid to the fluid state. When the steel or iron is in this semi-fluid, or thickish, condition, the introduction of the magnesium takes place smoothly. As it is not convenient in the manufacture of iron and steel for casting to cool the melt to such an extent that the magnesium can be introduced thereinto with safety, a preliminary alloy is formed in this manner, which is, when in a heated condition, added to the iron or steel to be deoxidised and cast in the same manner as other additions are made, such, for instance, as aluminium, ferro-silicon, or ferro-manganese. Iron and steel have but little affinity for magnesium, and in this respect act in a manner the opposite to that of copper, nickel, etc., but it is possible to obtain in the aforesaid manner a ferro-magnesium containing a small percentage of magnesium. In order to fully deoxidise 100 kilogrammes of iron or steel for casting from 15 to 50 grammes of magnesium are required, according to the quality of the iron or steel used. It is, therefore, necessary to add to 100 kilogrammes of iron or steel for casting from 1.5 to 5 kilogrammes of a preliminary alloy containing about 1 per cent. of magnesium. If additions of other metal, such as nickel or aluminium, are also to be made to the iron or steel these can, if desired, be introduced into the preliminary alloy, the said additions being, for instance, first alloyed with magnesium and this alloy being introduced into the iron or steel for the production of the preliminary alloy.

The End Connections of a Squirrel Cage Motor.

The increasing use of alternating-current three-phase power for general industrial purposes has brought about a considerable demand for motors of small size, for individual and small-group driving of machines in shops. In sizes of motors not over 25 b.h.p. it is customary to do away with complicated starting devices by the use of permanently short-circuited rotor connections, the motor being started by the simple closing of a main switch which admits energy to the stator windings and produces a rotary field, reacting on the rotor windings to give a mechanical torque.

The customary way of providing the short-circuiting rings or end connections of these rotor bars is somewhat cumbersome, and takes considerable time. Either a copper conductor is bent round the pro-



METHOD OF CONSTRUCTING END CONNECTIONS OF SQUIRREL CAGE MOTORS.

jecting ends of the lightly insulated bars which pass through the slots in the laminated core of the rotor, this conductor being mechanically secured either by soldering or other processes, or else a turned ring is expanded by heating and then shrunk on over the projecting lugs. Both these methods are subject to a certain amount of objection, as the combined effects of the heating due to the passage of heavy currents through the rotor windings and the vibration caused by the running of the machine, may result in loosening and displacement of the end connections, which may cause serious trouble in practice.

The well-known firm of Glasgow electrical engineers, Messrs. Mavor & Coulson, Limited, have recently adopted an improved system of dealing with their rotor end connections which is very interesting, and marks a step in advance. The rotor bars are threaded through the slots with a slight amount of insulation,

this being all that is necessary, as the potentials developed in a rotor circuit are never excessive, the power being shown in the heaviness of current. The rotor so prepared is then put into the sand of a moulding box, as shown in the annexed illustration, which is then moulded so as to leave a circular groove into which the ends of the bars project. The sand is very carefully and solidly packed so as to prevent any possibility of injury from hot metal to the parts of the insulation adjacent to the ends.

A quantity of molten brass or gun-metal is then run into the groove, so as to cast a ring round the projecting ends of copper bars. From three to four times as much metal as is actually required for the ring is poured through the mould so as to ensure its burning on to the ends of the bar. In the case of motors of large diameter it becomes necessary, on account of the risk of fracture of the ring during the contraction of the metal in cooling, to cast the ring in three or four segments, which are subsequently burned together. It is claimed that the construction of the rotor ring on this principle not only involves a considerable saving of time and, therefore, cheapens the cost of production, but also produces a much sounder job than was the case in the previous methods.

Wrought-iron Moulding Boxes.

The substitution of wrought-iron moulding boxes for those made of cast iron has, for certain classes of work, many advantages. In the first place they are practically unbreakable, and thus have a longer life than cast-iron boxes; further, they have the advantage of lightness. The illustrations show boxes of

SOME EXAMPLES OF WROUGHT-IRON MOULDING BOXES.

this nature manufactured by Messrs. Estler Bros., 25, Laurence Pountney Lane, London, E.C. They are made of wrought iron, of channel section, and as no patterns are required in their manufacture, can be made in any size, irrespective of quantity. The position of handles and pins can be varied to suit the desires of the founder. These boxes, the makers claim, are particularly suitable for use on moulding machines.

Trade Talk.

THE ROTHERHAM ELECTRICAL ENGINEERING COMPANY have started business at 39, High Street, Rotherham.

MR. J. F. GILL, consulting engineer, has opened an office at Scottish Provident Buildings, 25, Castle Street, Liverpool.

MR. A. VAIR TURNBULL, of Leith, has been elected to a seat on the Board of Furness, Withy & Company, Limited.

A FIRE which broke out on October 18, at Maryport, destroyed the Workington Iron and Steel Company's shipping offices.

A RECEIVING order has been made in connection with the affairs of Mr. W. H. Wass, metallurgist, of 286, Attercliffe Road, Sheffield.

MESSRS. BAILEY & CLAPHAM, Dalton Lane, Keighley, have recently put upon the market an oxy-acetylene gas apparatus for welding purposes.

THE DOVER ENGINEERING WORKS, LIMITED, have acquired from A. L. Thomas & Sons, Limited, the Dour Iron Foundry, Bridge Street, Dover.

MESSRS. R. F. HARVEY and J. H. PAGE, engineers and naval architects, Liverpool, trading under the style of Harvey & Page, have dissolved partnership.

ADMIRAL SIR ARCHIBALD DOUGLAS, G.C.V.O., K.C.B., and Mr. Malcolm Dillon have been elected directors of Palmers Shipbuilding and Iron Company, Limited.

MR. C. B. CATT has been elected a director of Henry Berry & Company, Limited, of the Croydon Works, Hunslet, Leeds, in place of Mr. C. W. Catt, resigned.

THE WHITEHEAD IRON AND STEEL COMPANY, LIMITED, of Tredegar, Monmouthshire, have appointed Mr. Wm. Arthur, of Manchester, as their sole agent for the Lancashire and Cheshire districts.

MR. H. B. N. MOTHERSOLE, barrister-at-law, London, has been appointed secretary of the Engineering and Shipbuilders Employers' Federation, in succession to Mr. James Robinson, resigned.

A FIRE broke out recently at the Woodside Iron Works, near Dudley, of Cochrane & Company, Limited, doing considerable damage to the cast-iron pipe department.

MR. C. J. B. COOKE has been appointed chief mechanical engineer at Crewe of the London & North-Western Railway, in succession to Mr. G. Whale, who has retired.

MR. C. J. BROWN has been appointed as engineer-in-chief of the North British Railway in place of Mr. J. Bell, retired. Mr. Brown was previously assistant engineer-in-chief.

MR. J. W. BAINBRIDGE, of 2, Fen Court, London, E.C., has been appointed London and district agent of Messrs. W. Arnott & Company, Coatbridge Boiler Works, Coatbridge, Lanarkshire.

THE STEAMCURATOR ENGINEERING COMPANY, of 30, Cross Street, Manchester, have opened a London office at 2, Norfolk Street, Strand, W.C., under the superintendence of Mr. Victor Coates, M.I.M.E.

MR. JUSTICE SWINFEN EADY, in the Companies' Winding-up Court, recently, made an order for the compulsory winding-up of the Inshaw Seamless Iron and Steel Tubes, Limited, on the petition of James Gemmell.

A DISSOLUTION of partnership is notified in connection with Messrs. H. Jarman and S. H. Siddall, constructional engineers, etc., Chapel Street, Levenshulme, and Mount Street, Stockport, who traded as H. Jarman & Company.

MR. J. C. BAYLEY of Brown, Bayley's Steel Works, Limited, Sheffield, and for many years London representative of the firm, has resigned in consequence of failing health. He will be succeeded by Mr. H. J. Skelton, his assistant.

At a meeting recently of the shareholders of the Metropolitan Engineering Association, Limited, it was decided to wind-up the company. For this purpose Mr. R. G. Sidford, of 1, New Court, Lincoln's Inn, was appointed liquidator.

On account of the very large increase in their business, Wallach Brothers, Limited, Royal London House, Finsbury Square, E.C., have removed their works, etc., from 50, Tenter Street South, Goodman's Fields, Whitechapel, E., to 20, Holywell Row, Finsbury, E.C.

At a recent meeting of the shareholders of the Metallic Manufacturing Company, Limited, it was decided to wind-up the company voluntarily, for which purpose Mr. W. F. Andrew, 209, West George Street, Glasgow, was appointed liquidator. The first meeting of creditors took place on October 28.

Messrs. Timothy Parkes & Sons, of Old Hill, Staffordshire, chain and general oddwork manufacturers for the export trade, are extending their plant to manufacture for the home trade. Mr. E. G. Rushton, who for the past eight years has been with Messrs. E. Tinsley & Company, Old Hill, has now joined their staff.

Mr. A. J. While, blast-furnace and steelworks manager at the Jarrow works of Palmers' Shipbuilding and Iron Company, Limited, who has been with the firm for seven years, has been appointed to succeed his father, Mr. J. M. While, in the management of the works of the Barrow Hematite Steel Company, Limited.

Messrs. Archibald Jeffrey & Company, engineers, and proprietors of the graving dock, Alloa, have received official intimation that the name of the firm is to be placed on the Admiralty list of contractors for carrying out hull, machinery, and boiler repairs on such vessels as can be accommodated in their dock.

An amalgamation has been arranged between the Aston Brass and Engineering Company, Limited, of Aston Lane, Birmingham, and Messrs. Isaac Whitehouse & Son, Albert Works, Aston Road, Birmingham, and in future the two concerns will trade at the Aston Works as the Aston Brass Company & Whitehouse, Limited.

The Worsley Mesnes Ironworks Company, of Wigan, have, for family reasons, converted their business into a private limited company. The management will continue the same as hitherto, no shares being offered to the public for subscription. The company will in future trade as the Worsley Mesnes Ironworks, Limited.

The works of the Birmingham Engineering Company, Limited, Hooper Street, Spring Hill, Birmingham, have been taken over by the Francis Barnett Manufacturing Company, who have discontinued the manufacture of machine tools, and are devoting themselves to the production of brass hexagonal nuts, screws, terminals, and other special parts turned from the bar.

S. Denison & Son, Limited, of Hunslet, Leeds, have received an order for 19 various sized weighing machines, and a 20-ton motor wagon weighbridge, from Messrs. J. Watson, for their new works at Selby. The company have also booked orders for an automatic train-registering weighbridge for Japan, and a Blake-Denison continuous weighing machine, for weighing furnace charges.

Owing to continued ill-health, Mr. Arthur Marsh is relinquishing his interest in the Roway Iron and Steel Works, West Bromwich. Messrs. Arthur and Walter Marsh have for some years carried on, in partnership, this old-established business, under the style of Edward Page & Sons. Mr. Walter Marsh is taking over his brother's interest, and will continue to trade under the old style.

The prospectus was recently published of the issue of 50,000 ordinary shares of £1 each of William Cooke & Company, Limited, Tinsley Steel, Iron, and Wire Rope Works, Sheffield. The shares were offered at a premium of 2s. per share, and they will rank for a full half-year's dividend for the financial year of the company ending in March next. The money is required for extensions.

An important extension scheme, it is reported, is to be carried out by Messrs. Smith & Company, proprietors of the Holborn Foundry, Nile Street, South Shields. The intention is to take in a large piece of land behind the present premises, and to erect upon it a new foundry about 240 ft. long by 50 ft. wide. Both the old and new shops are to be equipped with all the latest approved plant, while electric power will take the place of gas, and the buildings will also be lighted by electricity.

A limited liability company has been formed to take over and carry on the Richmond Iron Works, West Bromwich. These works have for many years been in the occupation of Messrs. Samuel Downing & Son, the proprietors of which are Messrs. L. C. Lewis & H. Lewis, who also hold controlling interests in Tupper & Company, Limited, of Bilston. The new company took possession on the 29th ult. The management will be vested in Mr. W. J. Randon, son-in-law of, and formerly junior partner with, the late Mr. Downing.

A circular has been issued giving notice that in pursuance of Section 188 (i.) of the Companies (Consolidation) Act, 1908, a meeting of the creditors of John Abbot & Company, Limited, will be held at the offices of Messrs. Monkhouse, Goddard & Company, 31, Mosley Street, Newcastle-upon-Tyne. The liquidators have also given notice that the holders of the first and second mortgage debentures have appointed receivers who are in possession of the whole of the assets of the company, and that very probably there will be nothing for the unsecured creditors.

The Engineers' Standardised Publications Association has just started business at Craven House, Kingsway, London, W.C. The primary objects of the Association, from the engineer's point of view, may be stated to be the classification, regulation, standardisation, etc., of all the price-lists, catalogues, circulars, etc., which every engineer receives in the course of each year. The Association proposes to promote the manufacturer's interests by ensuring the retention by the recipients, in a manner easy for reference, of all the lists, catalogues, and circulars that he issues in the course of the year.

We are informed that at a meeting of the board of Thomas Firth & Sons, Limited, recently, the following appointments were made:—Mr. F. C. Fairholme, of Nether Hall, Hathersage, a director of the company, to be the assistant managing director; Major Strange (late R.A.), of Brinkburn Grange, Dore, who has held a responsible position with the company for several years, to be an additional director. The following gentlemen, all of whom have been connected with the management of the company for many years, were appointed special directors:—Mr. Frederick Best, of Ringstead, Dore, who is also secretary of the company; Mr. Edward Dixon, of Whirlow Croft, Ecclesall; and Mr. Percy Fawcett, of Whirlow Brook, Sheffield.

A movement is on foot on the North-East Coast among the shipbuilders, engineers, iron and steel makers, and others, in connection with the fostering of local industries. It is considered that there should be a greater feeling of reciprocity between the shipbuilders and the engineers and the manufacturing firms, as, for instance, prevails on the Clyde, where the shipbuilders do everything in their power to keep as much work as possible on that river, or, at least, in the West Coast of Scotland. The North-East Coast is, to all intents and purposes, a self-contained area for the making of ships and engines. It may be necessary to go out of the district for some requisites, but in the main there are facilities for producing most of them near at hand, and thus it is regarded as well worth considering to what extent the circulation of the money could be kept on the North-East Coast instead of purchasing so largely at other centres.

Personal.

We regret to hear of the very serious illness of Professor Bauerman, the well-known metallurgist.

Sir W. Stephenson has consented to stand as Lord Mayor for the city of Newcastle for the ensuing twelve months.

The gross value of the estate of the late Mr. H. C. Trenery, of H. C. Trenery & Company, Union Iron Works, Sheffield, is £4,317.

Mr. C. I. Haden, of Trowbridge, has been elected President of the Institution of Heating and Ventilating Engineers for the ensuing year.

Property sworn at £71,792 17s. 8d. gross and £59,767 7s. 4d. net has been left by Mr. G. Burn, brass founder, of York House, Hall Green, Birmingham.

Mr. Godfrey Palmer, son of the late Sir Charles Mark Palmer, M.P., has been selected as the Liberal candidate for the Jarrow division at the next election.

Mr. T. Mather has been appointed Professor of Electrical Engineering at the Central Technical College, London, S.W., in place of the late Professor Ayrton.

The late Mr. W. Wright, chairman and managing director of Fleming, Birkby & Goodall, Limited, belting manufacturers, Halifax, left estate valued at £48,337 gross.

The late Mr. William Caird, a director of Caird & Company, Limited, engineers and shipbuilders, of Greenock, left personal estate in the United Kingdom valued at £58,842.

A memorial window has been placed in All Saints' Church, Wilden, as a memorial to the late Mr. Alfred Baldwin, M.P., by his colleagues on the board of directors of Baldwin's, Limited.

Mr. Charles Dorman, J.P., of Dorman, Long & Company, Limited, has accepted an invitation extended to him by the members of the Middlesbrough Unionist Association to become the prospective Unionist candidate for the constituency.

Mr. J. Kent Smith, who was for some time the chief metallurgist to the American Vanadium Company, has now left the United States and has become associated with the International Vanadium Company, Limited, 49 and 51, The Albany, Liverpool.

Mr. A. B. Hammond, who has left the Excelsior Steel and Iron Company, Limited, Swan Village, West Bromwich, to become a director and secretary of Samuel Downing & Son, Limited, Richmond Iron Works, West Bromwich, has been the recipient of a presentation from his late colleagues.

A portrait of the late Mr. S. Smith, of Nottingham, who died in 1882, has recently been presented to the Council of the Institution of Mechanical Engineers by his grandsons, who are connected with the firm of Sydney Smith & Sons (Nottingham), Limited, of the Basford Brass Works, Nottingham.

Mr. K. K. von Krogh, who has resigned his position with the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester, was recently entertained to a farewell dinner by the directors and staff of the company. Mr. Krogh is returning to Norway to establish himself in business as a consulting engineer.

The Denny Gold Medal, provided for by the late Mr. Peter Denny, LL.D., and awarded each session for the best paper read before the Institute of Marine Engineers, has been awarded this year to Mr. William P. Durnall (member), for his paper on "The Generation and Electrical Transmission of Power for Main Marine Propulsion and Speed Regulation."

Deaths.

Mr. P. Samson, late Engineer Surveyor-in-Chief to the Board of Trade, died last month, aged 67 years.

Mr. J. Austin, director of the Meadow Foundry Company, Limited, Mansfield, Notts., died recently, aged 85 years.

Mr. J. Timmins, chief engineer of the Barrow Hematite Steel Company, Limited, for many years past, died suddenly last month.

Mr. J. P. Liddell died at his residence, New Mills, recently, aged 65. The deceased gentleman was proprietor of the Canal Foundry.

The death took place recently of Mr. J. Reid, one of the founders of the Waverley Iron and Steel Company, Limited, Coatbridge, aged 65 years.

Mr. E. Foxall, of Messrs. E. & J. Foxall, engineers, of 68, Jordan Street, Liverpool, and 46, Regent Road, Bootle, died recently, aged 76 years.

The death took place at his residence at Droitwich, on October 1 last, of Mr. Henry M. Hingley, of the firm of N. Hingley & Sons, Limited, ironmasters, Netherton.

Colonel W. J. Burgess, who some years ago retired from the business of Messrs. W. J. & C. T. Burgess, engineers, Victoria Works, Brentwood, Essex, died recently aged 68 years.

Mr. John Martyn, of Airdrie, died suddenly at his residence there recently, aged 75 years. The deceased was head of the firm of Martyn Brothers, ironfounders, but he had retired from active business, not having recently enjoyed the best of health.

Mr. Archibald Hutcheson, engineer and ironfounder, Govan, Glasgow, died on October 15 last, aged 72 years. He was a member of the Institute of Naval Architects and of the Institution of Engineers and Shipbuilders in Scotland. He retired from active business about a year ago.

The death took place, recently, at his residence, The Villas, Leigh Lane, Leigh, near Manchester, of Mr. Alexander McGregor, of the well-known firm of Harrison, McGregor & Company, Limited, of the Albion Iron Works, Leigh. The deceased, who was born at Keith, N.B., had been in failing health many years.

Mr. James Hunter, of Hall, Russell & Company, Limited, Aberdeen Iron Works, Aberdeen, died on October 18 last. The deceased, who was 69 years of age, had been connected with the firm for 44 years. In 1884 he was assumed as a partner, and for many years was associated with the late Mr. A. Hall Wilson, upon whose death in 1899 he became senior partner.

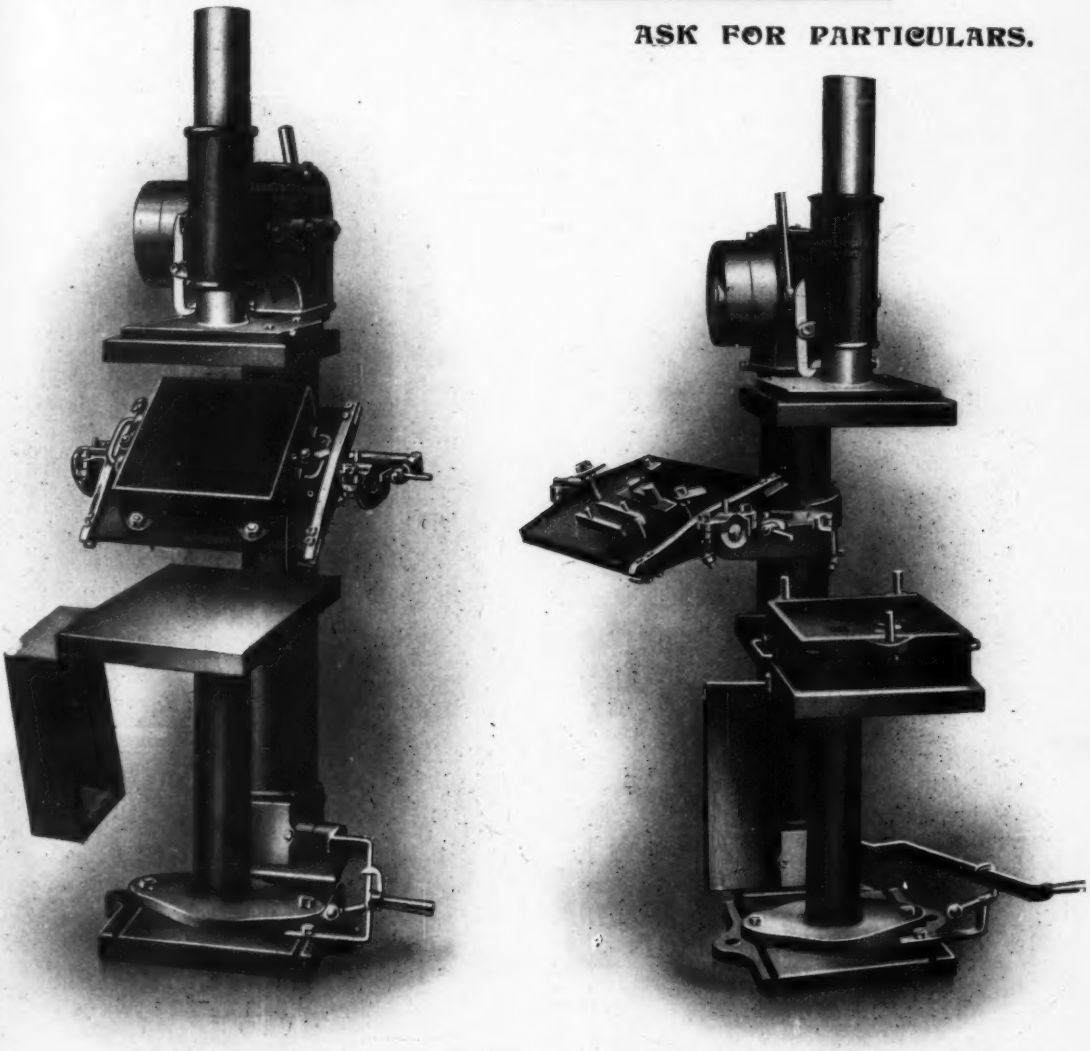
Mr. John Rollings died suddenly on October 17 at his residence, The Pines, Penn Road, Wolverhampton. The deceased gentleman, who was 59 years of age, was interected in the commercial life of the town and district, having been connected with the Star Engineering Company, the Briton Motor Company, the Sanitary Pipe Company (Horsehay), and Messrs. Rock & Company, brassfounders, Wolverhampton.

Mr. H. W. Young, a partner in the firm of Messrs. Youngs, manufacturers of lifting appliances, etc., Ryland Street Works, Birmingham, died on October 1 at the early age of 44 years. The deceased gentleman commenced his business career with Elliott's Metal Company, Selly Oak, with whom he remained seven years. In 1887 he joined his elder brother, Mr. D. T. Young, and they purchased the engineering business of John Williams, Ryland Street, and afterwards the business of W. Eades & Company, St. Peter's Place. These important businesses were amalgamated under the charge of the two brothers, and the firm became known as Youngs, manufacturing engineers, Ryland Street Works.

MOULDING MACHINES
OF EVERY DESCRIPTION.

The New "Puncher."

ASK FOR PARTICULARS.



EVERYTHING FOR YOUR FOUNDRY.

JAMES EVANS & CO.,
Britannia Works, BLACKFRIARS, MANCHESTER.

New Companies.

INCORPORATED SOCIETY OF IMPORTERS.—Limited by guarantee.

FRANCO-BRITISH ELECTRICAL COMPANY, LIMITED.—Capital £1,500 in £1 shares.

BRITISH ACETYLENE ENGINEERING COMPANY, LIMITED.—Capital £1,000 in £1 shares.

SAMUEL DOWNING & SON, LIMITED.—Capital £15,000 in £1 shares. Registered office: Richmond Iron Works, West Bromwich.

THOMAS SUTCLIFFE & COMPANY, LIMITED.—Capital £2,000 in £5 shares, to carry on the business of engineers, boiler-makers, etc.

UNITED PROCESS COMPANY, LIMITED.—Capital £50,000 in £10 shares, to carry on the business of manufacturers of armour plates, gun shields, etc.

JOHN EVANS, LIMITED.—Capital £10,000 in £100 shares, to carry on the business of ironfounders, etc. Registered office: Lower Forest Foundry, Morriston, Glamorganshire.

SAMUEL BROOKES & COMPANY, LIMITED.—Capital £1,500 in £1 shares, to carry on the business of engineers, manufacturers, and factors of tube fittings and tubes, tool makers, metal workers, etc.

J. YETTON & COMPANY, LIMITED.—Capital £5,000 in £1 shares, to adopt an agreement with J. Yetton, and to carry on the business of engineers, etc. Registered office: 4, Carr Street, Limehouse, E.

GEORGE SANDS & SON, LIMITED.—Capital £15,000 in £1 shares (3,000 preference), to take over the business of engineers, carried on by J. H. Sands and E. C. R. COX, at Colwick, Notts, as George Sands & Son.

CORUNDUM, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of manufacturers of crushed and graded corundum polishing, burnishing, and cleaning powder, etc. Registered office: 156, St. Vincent Street, Glasgow.

SRAWLEY & LANGLEY, LIMITED.—Capital £1,000 in £1 shares, to take over the business of a general brass-founder, stamper, and piercer, carried on by S. C. Srawley at Edward Road, Balsall Heath, Birmingham, as Srawley & Company.

CUNNINGTON & HARRIS, LIMITED.—Capital £5,000 in £1 shares (2,000 preference), to adopt an agreement with S. Harris and to carry on the business of electrical engineers, etc. Registered office: 21, North Audley Street, Grosvenor Square, W.

THOS. WILSON & COMPANY, LIMITED.—Capital £10,000 in £1 shares, to adopt an agreement with C. H. Holmes and A. D. Wilson, and to carry on the business of manufacturers' agents, engineers, etc. Registered office: 101, Leadenhall Street, E.C.

HANWAY ENGINEERING WORKS, LIMITED.—Capital £1,500 in £1 shares (500 pref.), to carry on the business of mechanical and electrical engineers, builders of inventors' models, etc. Registered office:—8, Hanway Street, Tottenham Court Road, W.

CHARLES HORTON & SONS, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of casters and founders of metals or metallic compositions, etc., and to adopt an agreement with Rev. T. C. Lawson and E. M. M. Horton, executors of the late Elizabeth Horton.

OWEN & DYSON, LIMITED.—Capital £10,000 in £1 shares, to take over the business of a manufacturer of wheels, axles, iron, steel, and brass castings and other hardware goods, contractor and merchant, carried on by R. Dyson, at Rotherham and elsewhere, as Owen & Dyson.

JOHN BUCKLEY (DUDLEY), LIMITED.—Capital £4,000 in £1 shares, to take over the business carried on at the Royal Works, Dunn Street, Dudley, as John Buckley, and to carry on the business of fender, fish-iron, grate, range knob, and ornamental wrought work manufacturers, etc.

BROCKLEY IRON WORKS, LIMITED.—Capital £2,500 in £1 shares, to carry on the business of ironfounders, etc., and to adopt an agreement with C. E. W. Talbot for the acquisition of the business carried on by him at Brockley, S.E. Registered office: 86, Foxbury Road, Brockley, S.E.

ORION STEEL COMPANY, LIMITED.—Capital £15,000 in 1,960 ordinary shares of £5 each, and 4,000 deferred shares of 1s. each, to take over the business of a steel manufacturer and merchant carried on by J. M. Fieschi at 49, Bailey Street, Sheffield. Registered office, 49, Bailey Street, Sheffield.

C. H. CATON & COMPANY, LIMITED.—Capital £15,000 in £1 shares, to adopt an agreement with C. H. Caton, to acquire the business carried on by S. Lund, T. P. Lund, and H. Lund, at Devonshire Works, Keighley, Yorks, as Samuel Lund & Sons, and to carry on the business of machine tool makers, etc.

JOHN RUSCOE & COMPANY, LIMITED.—Capital £10,000 in £1 shares (3,000 preference), to take over the business of mechanical engineers, carried on by J. Ruscoe & Company, Limited (in liquidation), at Hyde, Cheshire, and to adopt an agreement with W. H. Barker, the liquidator. Registered office: Henry Street, Hyde, Cheshire.

MORGAN ENGINEERING COMPANY, LIMITED.—Capital £1,000 in £1 shares, to acquire the business carried on at 14, Panton Street, Haymarket, S.W., as A. J. Morgan & Company; to adopt an agreement with A. J. Morgan and to carry on the business of ironfounders, engineers, etc. Registered office: 14, Panton Street, Haymarket, S.W.

GEORGE A. SHIPMAN & COMPANY, LIMITED.—Capital £8,000 in £1 shares, to take over the business of a steel manufacturer and merchant, carried on by G. A. Shipman at Imperial Chambers, Norfolk Row and Lumley Street, both in Sheffield, as George A. Shipman & Company. Registered office: Imperial Chambers, Norfolk Row, Sheffield.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

SOUND

STRONG, CLOSE-GRAINED

CASTINGS

Obtained by using

"TITANIUM THERMIT"

TINS READY FOR USE. ALL SIZES from 2 cwt. to 20 tons.

Prices and Particulars from

THERMIT LIMITED,

Telegrams: "FULMEN, LONDON."
Telephone: 3749 Central.

Works: 210a, Bow Rd., E.

27, Martins Lane,
Cannon Street, E.C.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, mor free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

Metals.	End Oct., 1909.	End Oct., 1908.
Iron—Scotch pig warrants ton	*57/0	*54/6
—Middlesbro' warrants . ton	51 4	48 5½
—W.C. M/nes Bessemer ... ton	62 6	60 0
—Stock, Scotch ... ... tons	1,000	1,000
Copper—Chili bars, GMB ton	£56 17 6	£61 13 9
—Stock, Europe and afloat tons	196,612	52,245
Tin—English ingots ... ton	£136 10 0	£133 10 0
—Straits ... ... ton	£137 17 6	£134 12 6
—Stock, London, Holland, U.S.A., and afloat ...tons	22,025	19,073
Lead—English pig ... ton	£13 10 0	£13 15 0
Spelter—Ord. Silesian ... ton	£23 5 0	£20 0 0
Quicksilver (75lb)... bottle	£8 17 6	£8 10 0
Antimony—Regulus ton	£29 10 0	£32 10 0 £34 0 0

* Settlement price. † Oct. 15th. ‡ Sept. 30th.

Castings.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (p'ain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	4 17 6	to	5 2 6
,, 3 to 4 in.	4 10 0	to	5 0 0
,, 5 to 8 in.	4 7 6	to	4 10 0
,, 10 to 16 in.	4 7 6	to	4 10 0
,, 18 to 24 in.	4 7 6	to	4 10 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 2 6	to	3 5 0

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 8s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 7s. 0d.; all per ton f.o.b., London. Copper (clean), £52 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £12 10s. 0d.; tea lead, £11 10s. 0d.; zinc, £19 0s. 0d.; all per ton delivered merchant's yard.

We have received from Messrs. Royce, Limited, Trafford Park, Manchester, a new booklet illustrating their specialities in electrically-driven cranes, etc. The booklet is composed of a large number of photographic reproductions, the photographs being of the appliances actually at work, and well illustrates the capacity of this firm to turn out first-class apparatus for handling light and heavy weights.

Gun Mounting Orders.—Mr. Gretton, in the House of Commons, on October 18, asked the First Lord of the Admiralty at what date was the order given to the Coventry Ordnance Works, Limited, for gun mountings, and when did the Government propose to submit a supplementary estimate to meet the expenditure incurred by the firm during the current financial year. Mr. McKenna: Pending arrangement of certain details, an order for gun mountings was placed conditionally with the Coventry Ordnance Works, Limited, on August 20th last. It cannot be stated at the present date whether any instalment under the scheme of payment will be earned in the present financial year, so that the question relating to the supplementary estimate with regard to the firm's order is premature.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

WET OR DRY.

Silco Cupola Bricks, 90% Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

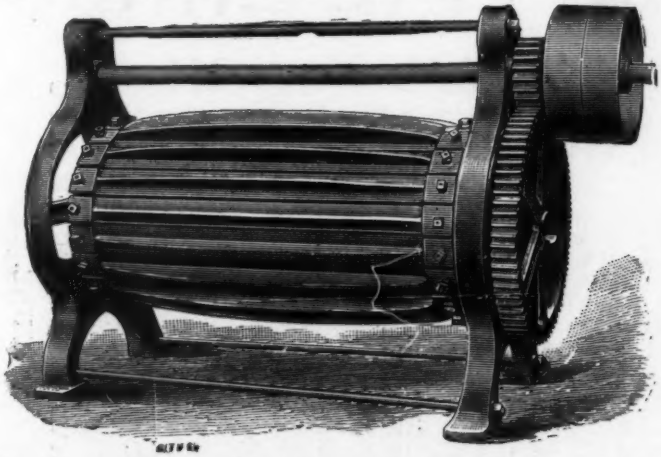
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

PATENT HYDRAULIC CORE MAKING MACHINE.

HYDRAULIC MOULDING MACHINE, Pattern L.

COMPLETE PIPE FOUNDRY EQUIPMENT.

The London Emery Works Co., PARK, TOTTENHAM, LONDON, N.

THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

Abrasive Wheels.
London Emery Works Co.
Jackman, J. W., & Co., Ltd.

Air Compressors.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Annealing.
Phillips, J. W & C. J.

Ash Crushing and Washing Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Barrels (Tumbling).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Sonnenthal, Selig, & Co.
Tilghman's Patent Sand Blast Co., Ltd.

Barrows.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.

Bellows.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Durrans, Jas., & Sons.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Blacklead.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Blowers.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Buffalo Forge Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Sonnenthal, Selig, & Co.
Thwaites Bros., Ltd.
Ward, T. W., Ltd.

Buffing and Polishing Machines.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Sonnenthal, Selig, & Co.

Casting Cleaners.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Cement.
Dyson J. & J.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Lowood, J. Grayson, & Co., Ltd.
Marshall & Co., Horace P.
Olsen, Wm.
Plasti-Kion Co.
Silent Machine and Eng. Co.

Chaplets and Studs.
Bush, Henry C.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Motherwell, Wm., & Co.
Olsen, Wm.
Wilkinson, T. & Co., Ltd.

Charcoal.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Walker, I. & I.

Charging Platforms.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Thwaites Bros., Ltd.

Coal Dust.
Cumming, Wm., & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Coke (Foundry).
Elders Navigation Collieries.

Coke Breakers.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W., & C. J.

Core Boxes.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.

Core Compounds.
Bush, H. C.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Wilkinson, Thos. & Co.

Core Gums.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Core Making Machines.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
Jones and Attwood.
London Emery Works Co
Marshall, H. P. & Co.
Phillips, J. W. & C. J.

Core Ovens.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hislop, R. & G.
Jackman, J. W. & Co., Ltd.
London Emery Works Co
Phillips, C. D.
Phillips, J. W. & C. J.

Core Ropes.
Bush, Henry C.
City of London Wood Wool Co.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Wilkinson, T. & Co.

Core Vents.
Bush, Henry C.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Cranes.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Jackman, J. W., & Co., Ltd.
Ward, T. W., Ltd.

Crucibles.
Hall, Charles, & Co.
Olsen, Wm.

Crucible Furnaces.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Simplex Coke Oven and Engineering Co., Ltd.

Crucible Furnaces (Lift-out)
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Phillips, J. W. & C. J.

Crucible Furnaces (Tilting)
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Crushing Mills.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Simplex Coke Oven and Engineering Co., Ltd.

Cupolas.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T. & Son.
Durrans, J. & Sons.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Marshall, H. P. & Co.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Cupola Linings.
Evans, J., & Co.
Harris & Pearson.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

Emery Grinders.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davis, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.

Emery and Glass Cloth and Glass Paper.
London Emery Works Co.

Emery Wheels.
Alldays & Onions Pneumatic Eng. Co., Ltd,
Jackman, J. W., & Co, Ltd.
London Emery Works Co.

Fans.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Buffalo Forge Co.
Davies, T. & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Jenkins, W. J. & Co., Ltd.
Phillips, J. W. & C. J.
Sonnenthal, Selig, & Sons.
Thwaites Bros., Ltd.

Firebricks.
Durrans, J. & Sons.
Dyson, J. & J.
Harris & Pearson.
Jackman, J. W., & Co., Ltd.
King Bros.
Lowood, J. Grayson, & Co., Ltd.
Pearson, E. J. & J.
Silica Firebrick Co.

Foundry Blacking.
Bush, Henry C.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Olsen, Wm.
Walker, I. & I.
Wilkinson, Thos. & Co., Ltd.

Foundry Brushes.
Bush, Henry C.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, C.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Phillips, J. W. & C. J.

Foundry Ladles.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Bush, Henry C.
Davies, T. & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
McNeil, Chas.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Foundry Rattlers or Fettling Drums.
Alldays & Onions
Davies, T., & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Simplex Coke Oven Co. and Eng. Co., Ltd.

THE BUYER'S GUIDE.—*Continued.*

Foundry Sand.
Dyson, J. & J.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd
Wilkinson & Co., Thos., Ltd.

Furnaces (Annealing).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Hislop, R. & G.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Brass).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Melting).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

Ground Gannister.
Durrans, J., & Sons.
Dyson, J. & J.
Evans, J., & Co.
Lowood, J. Grayson, & Co.
Silica Firebrick Co.
Walker, I. & I.

Grinding Machines and Tools.
Evans, J. & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Sonnenthal, Selig, & Co.

Hammers (Steam).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Thwaites Bros., Ltd.

Hay Band Spinning Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

Hoists.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Jackman, J. W., & Co., Ltd.
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Loam and Sand Mills.
Davies, T., & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman J. W., & Co., Ltd.
Marshall & Co., Horace P.
Ward, T. W. Ltd.

Melting Furnaces (Oil-fired).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Microscopes.
Swift, James & Son.

Mould Driers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Moulding Machines.
Bush, Henry C.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Simplex Coke Oven and Eng. Co., Ltd.
Whittaker, Wm., & Sons, Ltd.

Moulding Machines (Hand and Power).
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

Pig Breakers.
Evans, J., & Co.
Jackman J. W., & Co., Ltd.
Simplex Coke Oven and Eng. Co., Ltd.
Sonnenthal, Selig, & Co.

Pig-Iron.
Bradley & Sons, T. & I., Ltd.
Frodair Iron and Steel Co., Ltd., The

Plumbago.
Bush, Henry C.
Cumming, Wm. & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Olsen, Wm.

Plumbago—*cont.*
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Pneumatic Tools.
Jackman, J. W., & Co., Ltd.
Marshall, H. P. & Co.
Simplex Coke Oven & By-products Co.

Polishing Sundries.
London Emery Works Co.

Publications.
Eagland & Co., Ltd.
Griffin, Charles & Co., Ltd.

Pyrometers.
Alldays & Onions
Phillips, J. W. & C. J.

Recording Gauges.
Evans, J. & Co.
Jackman, J. W., & Co., Ltd.
Phillips, J. W & C. J.

Riddles.
Bush, H. C.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Simplex Coke Oven and Engineering Co., Ltd.
Wilkinson, Thos. & Co., Ltd.

Sand Blast Apparatus.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Tilghman's Patent Sand Blast Co., Ltd.

Sand Driers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

Sand Grinding Mills.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.

Sand Mixers.
Evans, J., & Co.
Halls Eng. Co
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

Sand Riddling, Separating and Sifting Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P. & Co., Ltd.
Simplex Coke Oven and Eng. Co., Ltd.
Sonnenthal, Selig & Co.

Sieves.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co, Horace P.
Simplex Coke Oven and Eng. Co., Ltd.

Smiths' Hearths.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Marshall & Co., H. P., Ltd.
Samuelson & Co., Ltd.
Sonnenthal, Selig, & Co.
Thwaites Bros., Ltd.

Steel Moulders' Composition.
Dyson, J. & J.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Lowood, J. Grayson, & Co., Ltd

Spades and Shovels.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Stone Flux.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Wilkinson & Co., Thos., Ltd.

Stoppers and Nozzles.
Dyson, J. & J.

Straw Ropes.
Bowes, Proctor, & Co., Ltd.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, William.
Wilkinson & Co., Thos., Ltd.

Testing Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.

Tuyeres (Firebrick).
Dyson, J. & J. [Ltd.
Lowood, J. Grayson, & Co.,

Welding. Thermit, Ltd

A FRODAIR MIXTURE

is not a ready-made mixture of different irons, nor an alloy, but a formula for the mixture of certain brands of pig. Such a formula may be composed of Frodair brands of pig-iron only, or of one or more Frodair brands along with ordinary pig-iron or scrap or both.

Further details from—

THE FRODAIR IRON & STEEL Co., Ltd., Fenchurch House, London, E.C.

FOR

IRONFOUNDERS' BLACKING, COAL DUST, ETC.

Registered **"SHALAGO"** Brand.

Write for Quotations to—

WILLIAM CUMMING & Co., LTD.,

IRONFOUNDERS' FURNISHERS.

WORKS— { Kelvinvale, Mills, Maryhill, Glasgow.
Whittington Blacking Mills, Chesterfield, Eng.
Sunnyside Blacking Mills, Falkirk, N.B.

TELEGRAPHIC ADDRESSES— { "Prudence, Glasgow."
"Cumming, Whittington, Chesterfield."
"Cumming, Blacking Mills, Camelon."

SITUATIONS VACANT AND WANTED.

CHEMIST, 35, seeks engagement. Experienced in Tool, Engine, Electrical, Jobbing & Repetition, Machine & Plate Moulding. Well up in Modern Cupolas and Air Furnaces. Chemical Analysis a speciality. Strict disciplinarian. First-class references. Address—Box 244, Offices of FOUNDRY TRADE JOURNAL, 165, Strand, W.C.

FOUNDRY PIG IRON. — Wanted — Purchasing or Commission Agents for Ireland, Wales and South of England. Popular Staffordshire Brand. Principals only. — Box 548, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

WANTED, Influential Foreign and Colonial AGENTS for High-class Firebricks and Silica Bricks.—Apply Box No. 243, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOR SALE AND WANTED.

MESSRS. C. A. ROBINSON & CO., Anchor Iron Wharf, East Greenwich, S.E., are Cash Buyers of every description of Scrap Iron and Steel, Brass, Copper, and all Metallic Residues. Telephone, 94 Deptford.

THE "ECLIPSE" SAND MIXER and GRINDER is the best for utilising Old Sand, Core Sands, Loam, and other Materials, mixed and prepared at lowest cost.—Apply HALL'S ENGINEERING CO., Hounds Gate Buildings, Nottingham.

FOR SALE AND WANTED.—*Continued.*

CHAINS for every purpose, including Mine and Incline Chains, Crane and Sling Chains, Steam Navvy and Dredger Chains, manufactured from tough and fibrous iron by skilled workmen.—MID-BRITISH CO., Corngraves Works, Cradley Heath.

PATTERN-MAKING.—All kinds of PATTERNS, large or small, made to customers' designs, by experienced workmen; accuracy and prompt delivery guaranteed.—LAMBERT BROS., Engineers, Snodland.

HIGH-CLASS Second-hand MACHINERY of every description in stock for Sale or Hire. Reasonable terms. Immediate delivery.—Send your enquiries to HARRY H. GARDAM, Staines.

BLOWING FANS.—One each 25 in. disc by 12 in. outlet, one 40 in. by 18 in., by Gunther; 11 in. by 5½ in., by Sturtevant Co.; 18 in. by 8 in., by R. Loyd & Co.
ROOTS BLOWERS.—Size H, by Samuelson, and No. 2, by Thwaites.
SAND GRINDER.—4 ft. dia., with outside bearings, by Smedley Bros.
ASH WASHER, for brass ashes, Mayer's patent, 32 in. dia.
RUMBLING BARREL, for brass castings, 22 in. d'a.
T. BROOK and CO.,
ENGINEERS, HUDDERSFIELD.

In Extra Crown 8vo. With 48 Illustrations. 3s. 6d. net.
LECTURES ON IRONFOUNDING.
By Prof. THOS. TURNER, M.Sc., A.R.S.M., F.I.C., Professor of Metallurgy in the University of Birmingham.
"Iron Founders will find much information in the book."—*Ryland's Iron Trade Circular.*

In Crown 8vo. Cloth. With 102 Illustrations. 6s. net.
A HANDBOOK ON METALLIC ALLOYS.
Their Structure and Constitution.
By GILBERT H. GUILLIVER, B.Sc., F.R.S.E.
"Probably the clearest and best exposition of the portion of the field with which he treats that has hitherto appeared in the English language."—*Engineer.*

Second Edition, Revised. Fully Illustrated. 21s. net.
ELECTRIC SMELTING & REFINING.
By Dr. W. BORCHERS and W. G. McMILLAN, F.I.C.
"Comprehensive and authoritative . . . ; full of valuable information."—*Electrician.*

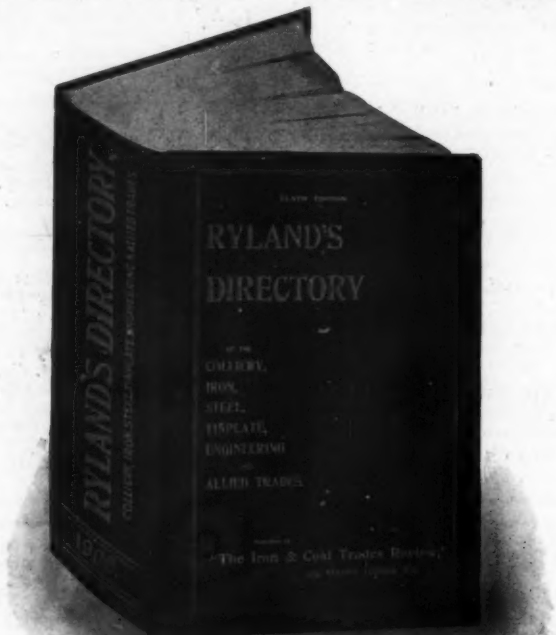
LONDON: C. GRIFFIN & CO., LTD., EXETER ST., STRAND.

CORE ROPINGS,
Straw Ropes and Wood Wool Ropes, from ¼ in. to 2 in. Largest Stock.
— CRUCIBLES, —
Core Gum, Plumbago, &c. Cheapest and Best.
STEEL WIRE BRUSHES
For all purposes.
Carriage Paid quotations on application.
WILLIAM OLSEN, 74, Cogan St., HULL.

GEORGE LONGDEN & SON, LTD.,
MANUFACTURERS OF
GROUND GANNISTER for Lining all kinds of Furnaces.
ALSO SOLE MANUFACTURERS OF
"Longden's" Celebrated Steel Moulders' Composition.
Specially prepared for Bessemer, Siemens, and Crucible Steel Castings, Cores, &c.
NEEPSEND, SHEFFIELD.

IMPORTANT NOTICE.

We are sorry and glad to inform our clients that



is out of print, sorry because we are bound to disappoint somebody, glad because of the increasing demand for this useful publication. We are in consequence of the above, making earlier arrangements and will produce RYLAND'S DIRECTORY, 1910, in January.

Advertisers please note that we have important advt. space to let and can now give special positions.

RATES FOR ADVERTISEMENTS.

Coloured insets opposite any selected vacant position ... £10 per page.
Ordinary advertisements ... ... £6 ,, ,,
The above prices include one copy (cloth) of the Directory.

EAGLAND & Co., Ltd., Publishers.
165, Strand, London, W.C.

Telegrams: "Zacatecas, London." **Telephone: 2346 Gerrard.**

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE NO.	NAME.	DESCRIPTION.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
—	Alldays & Onions, Ltd.	Foundry Plant	Birmingham	Alldays, Birmingham	328 Victoria
C. ii.	Bradley, T. & I., & Sons, Ltd.	Pig-Iron	Darlaston	—	—
C. iii.	Buffalo Forge Co.	Fans and Blowers	Caxton House, London	Buffaloes, London	Victoria 420.
717	Bush, Henry C.	Foundry Specialists	The Strand, Derby	Bushes, Derby	Nat. Tel. 143 & 387.
774	Cumming, William, & Co., Ltd.	Blacking Manufacturers	Maryhill, Glasgow	Prudence, Glasgow	P.O. M. 25
715	Davies, T., & Sons	Cupolas	West Gorton, Manchester	Tuyere, Manchester	70 Openshaw
771	Durrant, Jas., & Sons	Foundry Equipment	Penistone, nr. Sheffield	Durrans, Penistone	—
714	Dyson, J. & J.	Ground Gannister	Sheffield	Dyson's, Stannington	702 Sheffield
769	Elders' Navigation Collieries Ltd.	Foundry Coke	Cardiff	Elder, Maesteg	10
720 & 767	Evans, J., & Co.	Foundry Requisites	Manchester	Ladles, Manchester	2297
774	Frodair Iron & Steel Co., Ltd.	Pig-Iron	5, Fenchurch Street, E.C.	Frodair, London	—
775	Griffin, Chas., & Co., Ltd.	Publications	Exeter Street, Strand, W.C.	—	—
718	Hall, Charles & Co.	Foundry Requisites	Dantzic Street, Manchester	—	—
713	Harris & Pearson	Cupola Linings	Stourbridge	Fireclay, Stourbridge	7 Brierley Hill
714	Hislop, R. & G.	Gas Engineers	Paisley	Gas, Paisley	321 Paisley
C. iv.	Jackman, J. W., & Co.	Foundry Requisites	Caxton House, S.W.	Molders, London	30 Victoria
—	Jenkins, W. J., & Co.	Gas Cleaning Fans	Retford	—	—
714	King, Bros.	Cupola Bricks	Stourbridge	—	—
772	London Emery Works Co., Ltd.	Foundry Requisites	Park, Tottenham	Naxium, London	99 Tottenham
768	Lowood, J. Grayson, & Co., Ltd.	Ganister, Cupola Blocks, &c.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
—	Marshall, H. P., & Co.	Core Machines	Leeds	Specialty, Leeds	1909 Leeds
717	McNeil, Chas.	Steel Ladles	Kinning Park, Glasgow	McNeil, Glasgow	X 155
775	Olsen, William	Plumbago and Blacking	Cogan Street, Hull	—	—
718	Phillips, Chas. D.	Foundry Core Ovens	Newport, Monmouthshire	Machinery, Newport	13 & P.O. 576
718	Phillips, J. W. & C. J.	Foundry Requisites	23, College Hill, E.C.	Colloquial, London	10122 Central
C. iii.	Plasti-Kion Co., The	Iron Cement	Caxton House, S.W.	—	—
—	Proctor, Bowes & Co.	Straw Ropes	Newcastle-on-Tyne	Proctor Bowes, Newcastle-on-Tyne	Nat. 1683 Centr'l
716	Samuelson & Co., Ltd.	Blowers	Banbury	Samuelson, Banbury	—
717	Selig, Sonnenthal & Co.	Foundry Separator	85, Queen Victoria Street, E.C.	Selig, London	341 Bank
—	Silent Machine & Engineering Co.	Foundry Cement	2, Savile Street, Sheffield	Forward, Sheffield	189, 1472, &c.
770	Silica Firebrick Co.	Ground Ganister	Oughtibridge	Silica Co., Oughtibridge	—
718	Stonehouse Works Co.	Wood, Wool, Core Ropes	King Edward's Rd., Birmingham	Tailboard, Birmingham	3069 Cl. (3 lines)
—	Swift, James, & Son	Microscopes	81, Tottenham Court Rd., London	Prisms, London	—
769	Thermit, Ltd.	Welding	27, Martin's Lane, E.C.	Fulmen, London	3749 Central
C. ii	Tilghman's Patent Sand Blast Co., Ltd.	Sand Blast Apparatus	Broadheath, nr. Manchester	Tilghmans, Altrincham	14
719	Thwaites Bros., Ltd.	Foundry Plant	Bradford	Thwaites, Bradford	325 Bradford
C. ii.	Walker, I. & I.	Foundry Blackings	Rotherham	—	—
—	Ward, T. W., Ltd.	Cupolas, Loam Mills, &c.	Albion Works, Sheffield	Forward, Sheffield	189, 1472, &c.
714	Whittaker, W., & Sons, Ltd.	Moulding Machines	Oldham	—	—
717	Wilkinson, Thos., & Co., Ltd.	Foundry Requisites	Middlesbrough	Blacking. Middlesbro'	419

STOURBRIDGE FIRE BRICKS

Of Best Quality for Lining Cupolas in Stock,

ALSO MADE TO ANY DESIGN.

Linings Stocked to Customers' Plans to ensure IMMEDIATE DELIVERY.

All kinds of Fireclay Goods of Highest Quality.

HARRIS & PEARSON, STOURBRIDGE.

Telegrams:—"FIRECLAY, STOURBRIDGE." **Telephone:—No. 7 Brierley Hill.**

FIRE BRICKS & CLAY

CUPOLA BRICKS.

BEST QUALITY.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

KING BROTHERS,
(STOURBRIDGE) Ltd.,
STOURBRIDGE.

EFFICIENT and ECONOMICAL HEATING
OF
STOVES,
ANNEALING OVENS,
FURNACES, Etc.

R. & G. HISLOP,
GAS ENGINEERS,
UNDERWOOD HOUSE, PAISLEY.

Sole Makers of **"PEHRSON'S PATENT STEEL MOULDERS' GREENSAND."**

GROUND GANNISTER, STEEL MOULDERS' COMPOSITIONS, SILICA CEMENT.

Gannister Bricks, Fire Bricks, Stoppers and Nozzles. Crucible Clay for all Purposes.

J. & J. DYSON, SHEFFIELD GANNISTER WORKS, ATTERCLIFFE ROAD, SHEFFIELD.
Telegrams—"DYSON'S, STANNINGTON." Telephone—No. 702 SHEFFIELD.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.

The most complete and efficient machine hitherto introduced to Engineers.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS
Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,
SUN IRON WORKS, *OLDHAM.*

ACTUAL MAKERS

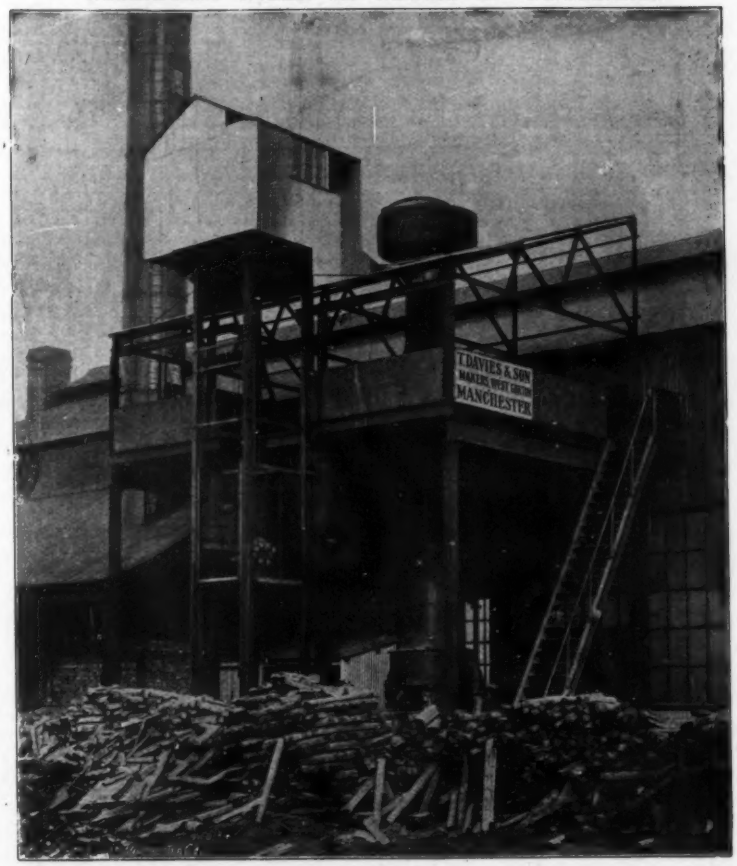
OF ALL TYPE OF

FOUNDRY CUPOLAS,

LADLES,

CHARGING PLATFORMS, CRANES, HOISTS, ROOTS' BLOWERS,
FOUNDRY RATTLERS, SAND MILLS, CORE STOVE DOORS, Etc.

STANDARD SIZES IN STOCK OR PROGRESS.



T. DAVIES & SON,

RAILWAY IRON WORKS, WEST GORTON, MANCHESTER.

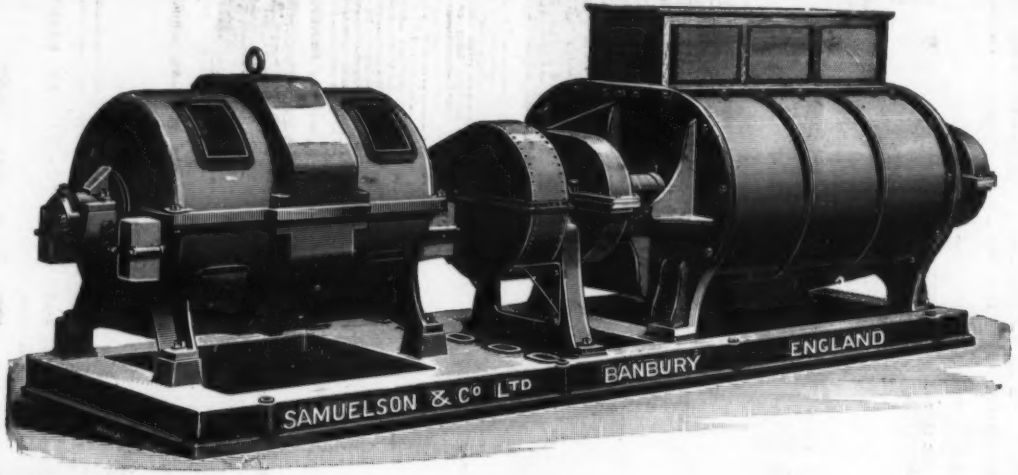
ON ADMIRALTY LIST.

TELEGRAMS—"TUYERE, MANCHESTER." NAT. TELEPHONE—No. 70, OPENSHAW.

SAMUELSON & Co., LTD., BANBURY, ENGLAND,

CONTRACTORS TO THE ADMIRALTY, WAR OFFICE, COLONIAL and FOREIGN GOVERNMENTS.

For Ordinary or High Pressures up to 10 lbs. per square inch.



OVER **9,000** MADE AND SOLD.

MANUFACTURERS OF

ROOTS' "ACME" BLOWERS,

Driven by Electric Motor, Simple or Compound Steam Engine.

Also Makers of

SMITHS' HEARTHS, FOUNDRY MOULDING MACHINES, &c.

Full particulars sent on application. **See our Advertisement every alternate month.**

FOUNDRY REQUISITES of Every Description

In Stock for Prompt Delivery.

PIG IRON, FOUNDRY COKE, GANISTER, LIMESTONE, SAND, ETC.

Also Manufacturer of WOOD WOOL CORE ROPE

Which is far superior to Straw Rope, and other similar material on the market. Sizes ½ in. to 2 in. diameter in stock.

Prices and Samples on Application.

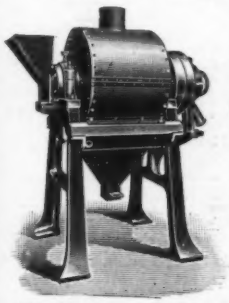
HENRY C. BUSH, COMPLETE FOUNDRY SUPPLIER, DERBY.

Tel: 143 & 387. Tele: Bushes, Derby.

Selig, Sonnenthal & Co.

... SOLE AGENTS FOR THE ...

PATENT FOUNDRY SEPARATOR



For Recovering Metal from Foundry Slag, . . Ashes, &c. . . . . Works Automatically . . without water or dust.

The slag contains from 30 to 40 per cent. of metal, half to three-quarters of which is recovered by this machine, and by this saving quickly repays the first cost.

The recovered metal can be melted again without further treatment.

Small amount of power required.

Occupies little space.

Can also be used for other purposes—crushing fire-bricks, foundry sand, coal and coke, &c.

85, QUEEN VICTORIA ST., LONDON, E.C.

8½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 20 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical or metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS, GLASGOW.
8½"

Can also be made in Aluminium.

ON ADMIRALTY, WAR OFFICE, and INDIAN OFFICE LISTS.

COAL DUST.

A good Coal Dust is worth a good price, because it saves labour and gives a good appearance to the Casting. Our Coal Dust is made from Best Durham Coal, and is screened into several different sizes to suit different kinds of work—from finest flour for light work to pin-head size for heavy work.

We send it to all parts of the country. The quality and grading are so good that high railway rates to distant places do not put us out of count.

Send for Free Trial Sample and Price.

THOMAS WILKINSON & CO., LTD, FOUNDRY STORES, MIDDLESBROUGH.

CHARLES D. PHILLIPS'

THE ORIGINAL FIRM.
— Established 1857. —

Registered and Improved No. 366,812

FOUNDRY CORE OVEN

(Self-contained).

Head Office—
EMLYN WORKS, NEWPORT, MON.
(And Gloucester).
ESTABLISHED 42 YEARS.

CHAS. HALL & CO.,
FOUNDRY REQUISITE MAKER,
DANTZIC ST., MANCHESTER.
TELEPHONE No. 5814, CITY.

STEEL WIRE BRUSHES.

Chaplets and Studs a Speciality.

WOOD WOOL CORE ROPES,

WE ARE

ACTUAL MANUFACTURERS (NOT FACTORS),

Of all Sizes ¼ to 2½.

BUY DIRECT. DON'T BE MISLED.

Buying per 1000 yards, you cannot measure it. . . . Buy by guaranteed weight.

FROM STONEHOUSE WORKS, CO., KING EDWARD'S ROAD, BIRMINGHAM

TELEPHONE: No. 3069, "CENTRAL 3-LINES." WORKS: "PERRY BAR." TELEPHONE: 237 EAST. TELEGRAMS: "TAILBOARD, BIRMINGHAM."

WE PUBLISH THE MOST COMPLETE CATALOGUE OF

MODERN FOUNDRY EQUIPMENT.

For 27 years our name has been a guarantee of quality.

WRITE FOR NEW LISTS SINCE PUBLISHED.

Rockwell Lift-out and Tilting Crucible Furnaces.
" Simplex Melting Furnaces (Oil Fired).
Sand Mixing Machines. Coke Breakers.
Small Cupolas.
Ash Crushing and Washing Machines.
Bristol Indicating, Switchboard, Portable and Recording Electric Pyrometers for Blast Furnaces, Steel Works, Molten Metal, Hardening, Annealing, Testing, etc.

J. W. & C. J. PHILLIPS,

23, COLLEGE HILL, CANNON STREET, **LONDON, E.C.**

Contractors to the War Office, Admiralty, India Office, Crown Agents for the Colonies, British and Foreign Railway Companies.

FOUNDRY PLANT.

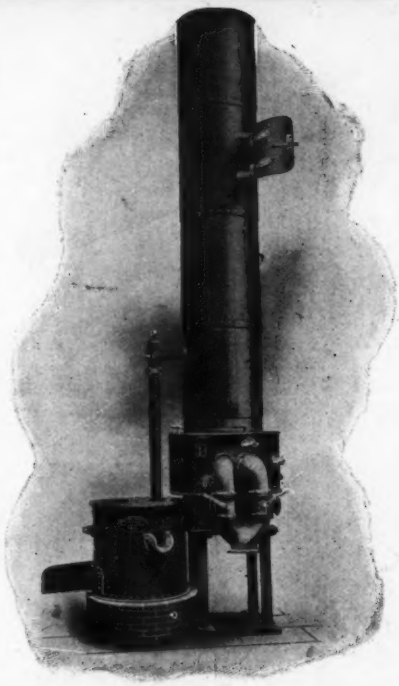
"Rapid" Cupolas,

with or without receivers or drop bottoms.

Roots' Blowers,

belt, steam-engine, or electro-motor driven.

Charging Platforms, Hoists, and Ladles.



ECONOMICAL RESULTS GUARANTEED.

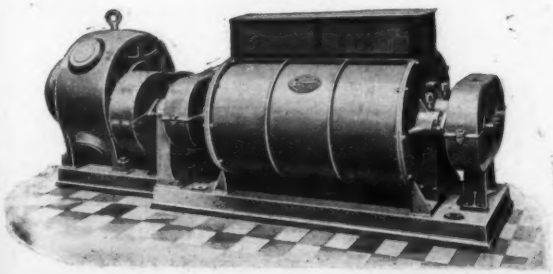
We are also Manufacturers of Steam Hammers, Smiths' Hearths, Centrifugal Pumps and Fans, High-Speed Engines, and the "Bradford" Patent Boiler Feed Pump.

We are the original makers of "Rapid" Cupolas as under Stewart's Patent. We make this intimation as other makers are introducing this description, which had become established as a synonym of Stewart's Cupolas.

CONTRACTORS TO HIS MAJESTY'S GOVERNMENT.

THWAITES BROS., LTD.,

Vulcan Ironworks, BRADFORD.



Telegrams—
"THWAITES, BRADFORD."

Telephone—
No. 325 BRADFORD.

London Office:
98 & 98, Leadenhall Street, E.C.

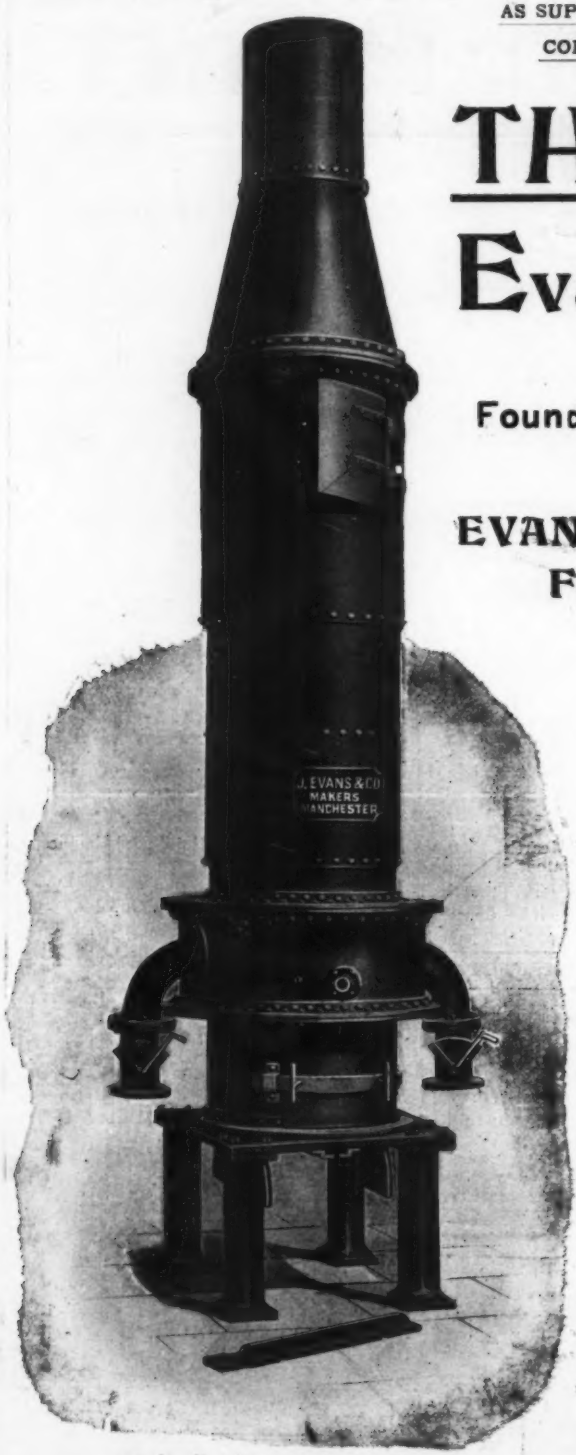
Catalogues on Application.

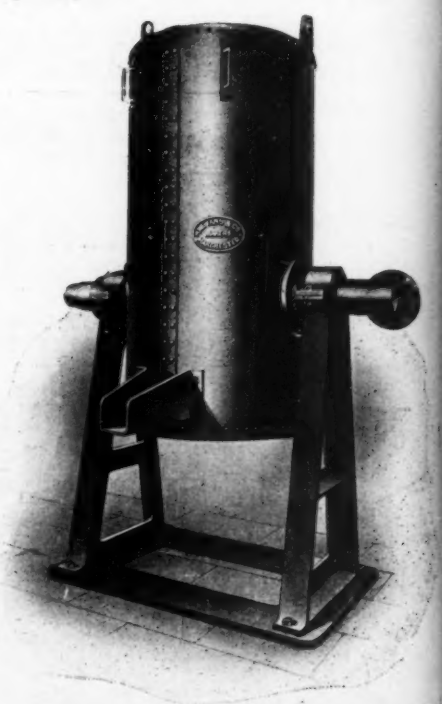
AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE,
COLONIES, AND FOREIGN GOVERNMENTS.

THE Cupola.
Evans's Rapid.

Foundries Completely Furnished.

EVANS'S NEW CUPOLETTE
For Emergency Work.





Telegrams: "LADLES, MANCHESTER."

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.